Geographic Information Systems (GIS)

Tutorial and Overview of Esri's ArcGIS 10.2

Shannon Rees
Engility/GFDL

Outline

- What is GIS?
- How it Works
- Data Types
- Climate/Meteorology Uses
- Getting Started
- Tutorial 1: Animation
- Tutorial 2: 3D Analyst

What is a GIS?

It's not just for drawing maps

"A computer system for capturing, storing, checking, and displaying, data related to positions on Earth's surface. GIS can show many different kinds of data on one map. This enables people to more easily see, analyze, and understand patterns and relationships."

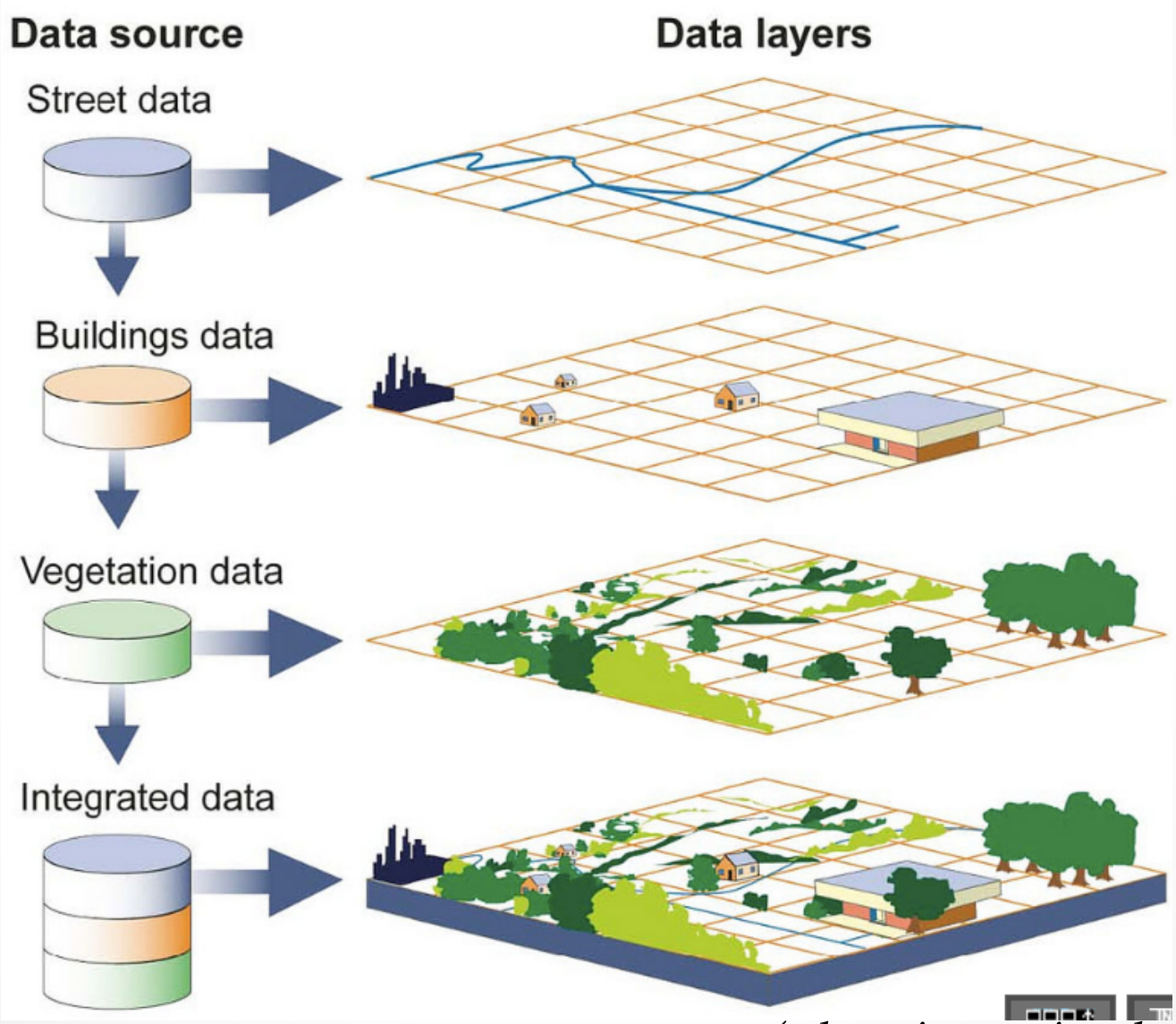
(education.nationalgeographic.com)

What is a GIS?

- First developed in 1960s by Dr. Roger Tomlinson for the Canada Land Inventory

- Used by: city planners, emergency managers, natural resource managers, transportation companies, marketing, census bureau, power companies, police departments, USGS, U.S. Military, NWS, Google

How it Works



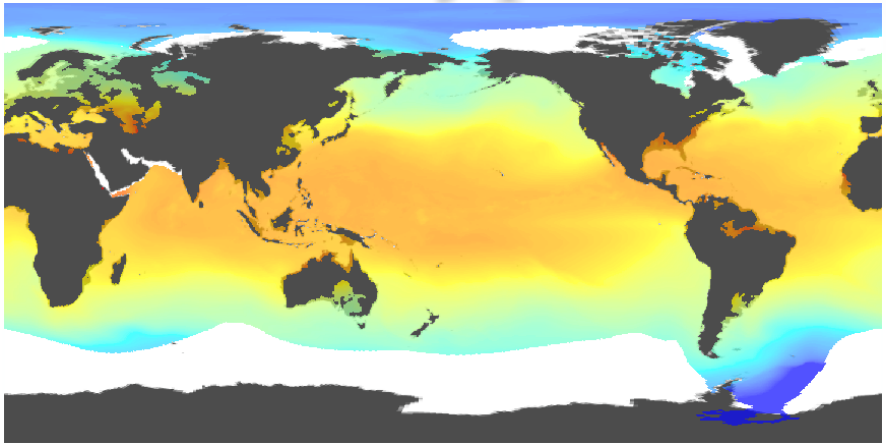
(education.nationalgeographic.com)

ArcGIS Interfaces

- ArcCatalog:
  - Best way to move/reorganize map files and folders
  - Edit metadata and preview layers
- ArcMap:
  - Central application
  - Create, display, and edit maps
- ArcScene:
  - 3D analyst for small spatial datasets
  - Better optimized for 3D analysis
- ArcGlobe:
  - newer 3D analyst application
  - 3D modeling of very large landscapes

Data Types

1. Raster



- A matrix of cells or pixels organized on a grid
- Each cell has a value representing information
- Examples:
  - Pictures scanned in (aerial photographs)
  - Continuous data (temperature, digital elevation model (DEM), satellite images)
  - Discrete data (land use, soils data)

Rasters

- Advantages:
  - Simple data structure
  - Fast overlays with complex datasets
  - Advanced spatial and statistical analysis

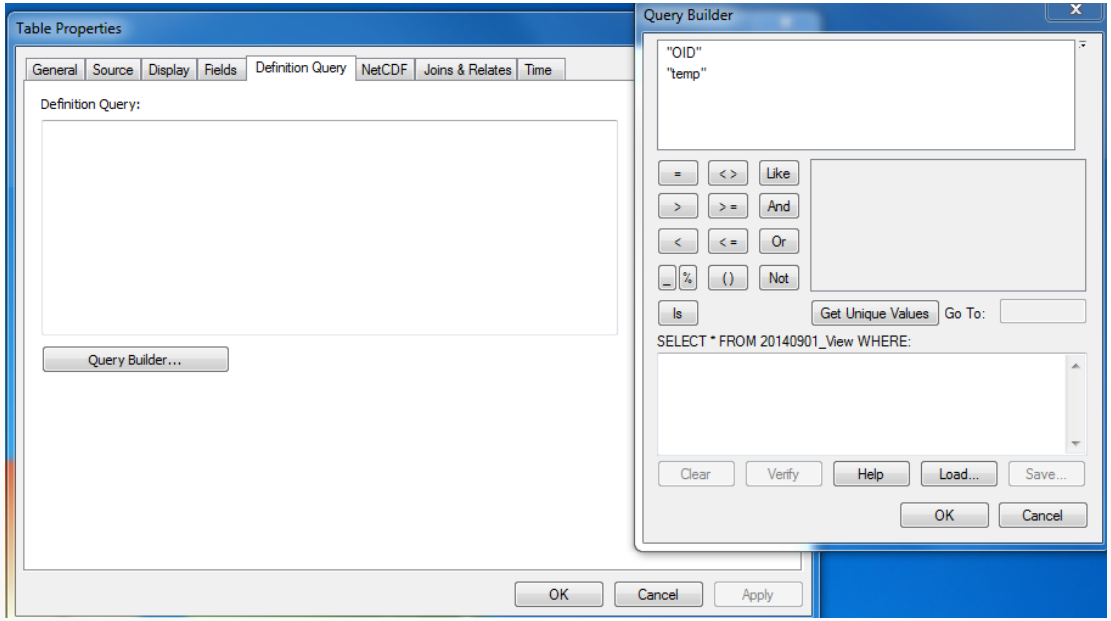
- Disadvantages:
  - Spatial inaccuracies due to limits from cell dimensions
  - Loss of precision from restructuring data
  - High resolution data sets are high cost in disk space and processing speed

Data Types

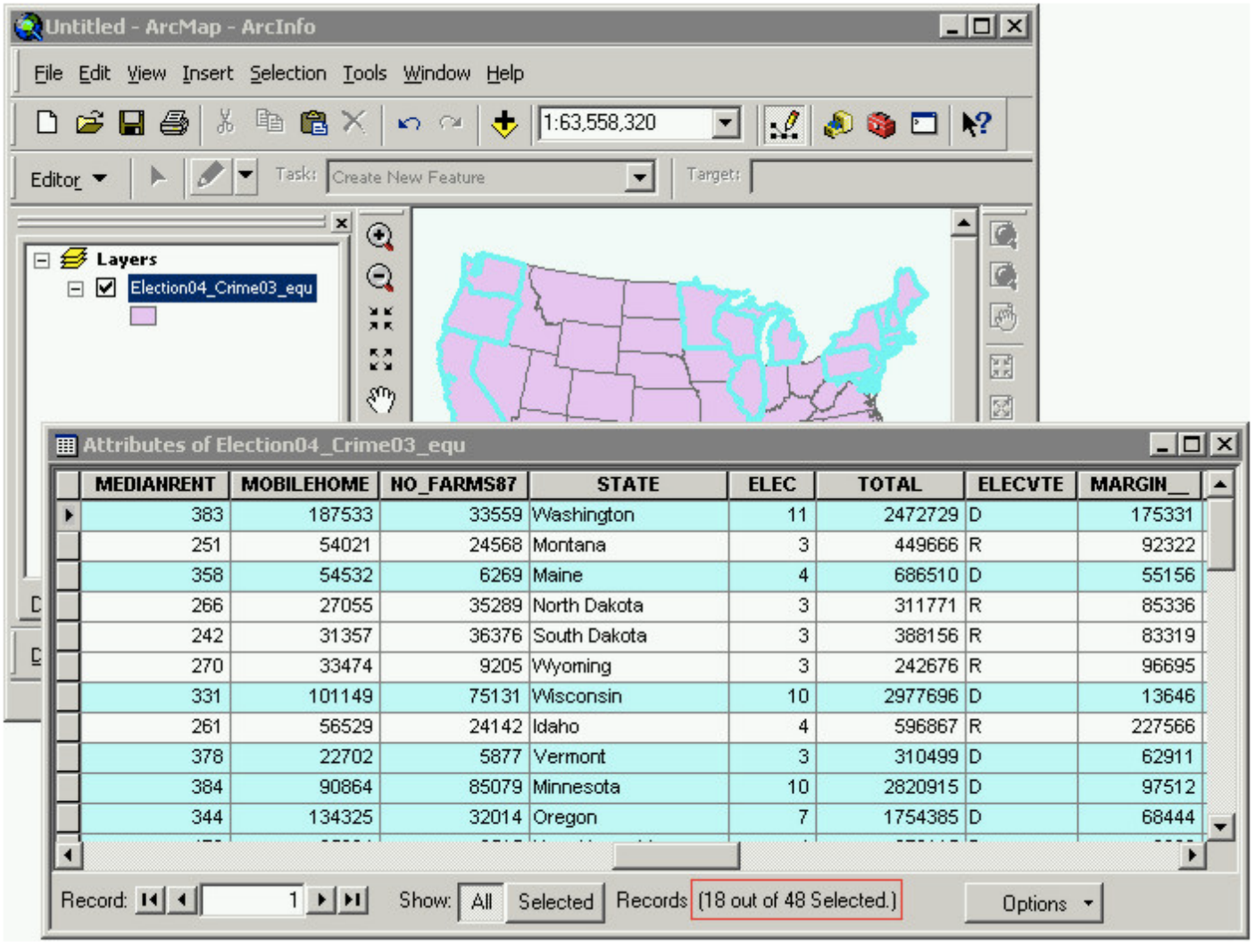
2. Tabular (Attribute Tables)

   A database or tabular file containing information about a set of geographic features

   - each row represents a feature and each column represents one feature attribute
   - Attribute values can be used to find, query, and symbolize features or raster cells



Tabular


Untitled - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
1:63,558,320
Editor
Task: Create New Feature
Target:
Layers
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Attributes of Election04_Crime03_equ
MEDIANRENT MOBILEHOME NO_FARMS87 STATE ELEC TOTAL ELECVTE MARGIN_
383 187533 33559 Washington 11 2472729 D 175331
251 54021 24568 Montana 3 449666 R 92322
358 54532 6269 Maine 4 686510 D 55156
266 27055 35289 North Dakota 3 311771 R 85336
242 31357 36376 South Dakota 3 388156 R 83319
270 33474 9205 Wyoming 3 242676 R 96695
331 101149 75131 Wisconsin 10 2977696 D 13646
261 56529 24142 Idaho 4 596867 R 227566
378 22702 5877 Vermont 3 310499 D 62911
384 90864 85079 Minnesota 10 2820915 D 97512
344 134325 32014 Oregon 7 1754385 D 68444
Record: 1
Show: All Selected
Records (18 out of 48 Selected.)
Options

Data Types

3. Vector

(www.lib.uwo.ca)

- Good for representing non-continuous data
  - rivers, political boundaries, roads, mountain peaks
- Features are represented as:
  - Points
  - Lines/routes
  - Polygons/regions
  - triangulated irregular networks (TINs)

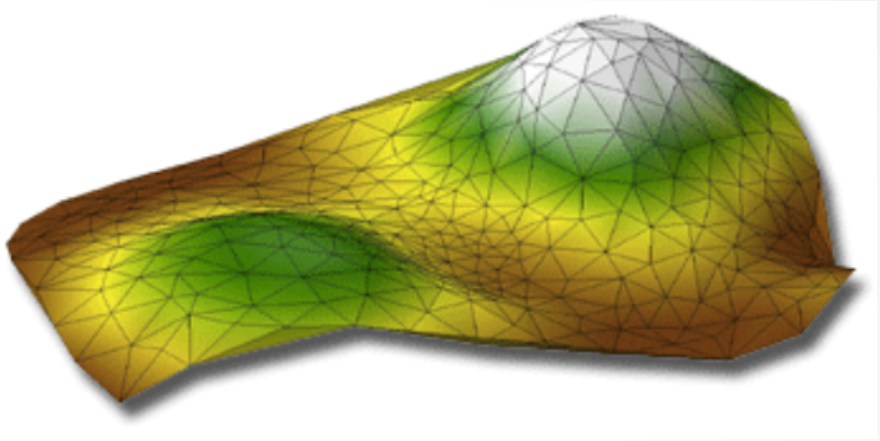
Vectors

- Advantages:
  - Topology can be completely described
  - Accurately represent true shape and size
  - Makes nice maps while conserving disk space

- Disadvantages:
  - Complex data structures
  - Simulation is difficult
  - Expensive to display and plot with high quality color

Data Types

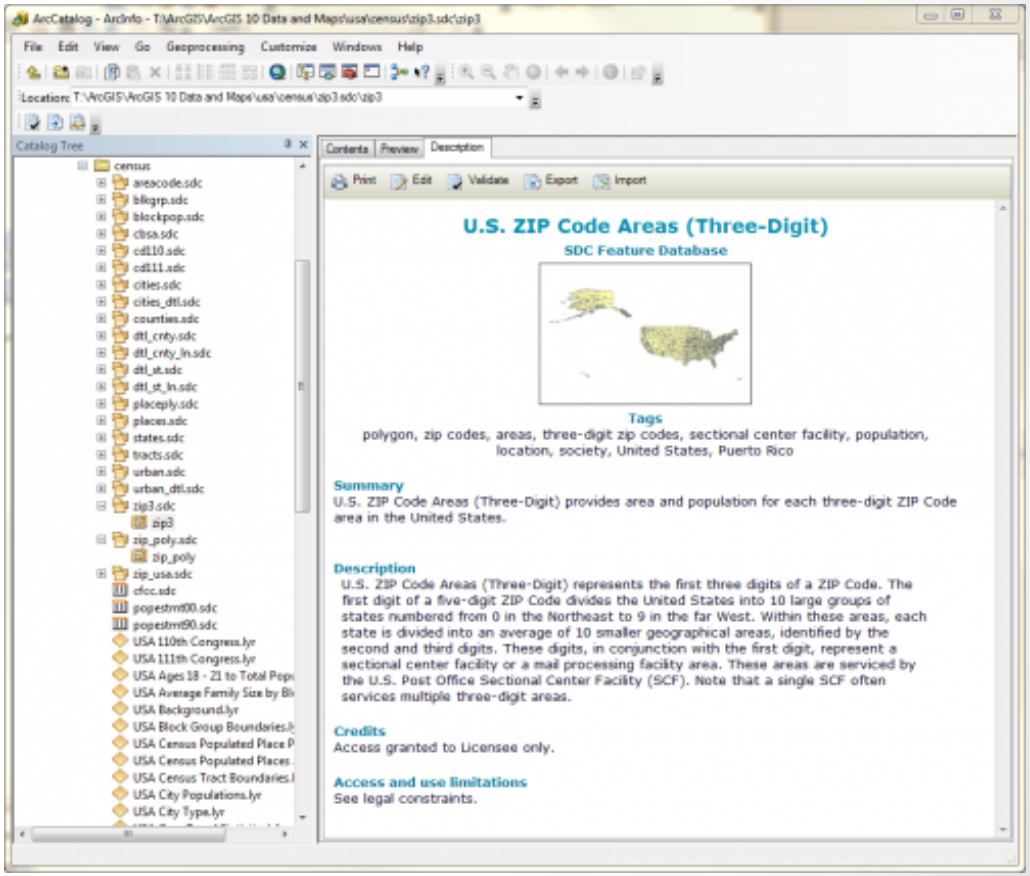
4. TINs (vector)
   - Digital means to represent surface morphology
   - Constructed by triangulating a set of irregular vertices
   - Higher resolution where surface is variable
   - Maintains precision of input data while modeling values between known points
   - More expensive than DEMs
   - Allow calculations of planimetric area, surface area, and volume



www.scisoftware.com

Metadata

- Important description of all types of data:
  - How accurate is it?
  - How recent?
  - Are there restrictions on its use?
- Different styles are available
- To view:
  - right click layer, data dropdown menu, view data description
  - or go to properties, source tab
- Metadata editing tools in ArcCatalog



ArcGIS

Advantages

- GUI makes many tools accessible
- 3D animation capabilities
- Analysis results can be understood by non-expert viewers
- May find patterns and trends in results that would not otherwise be visible
- Easier to spot errors and anomalies
- Standardized spatial data format makes sharing easier

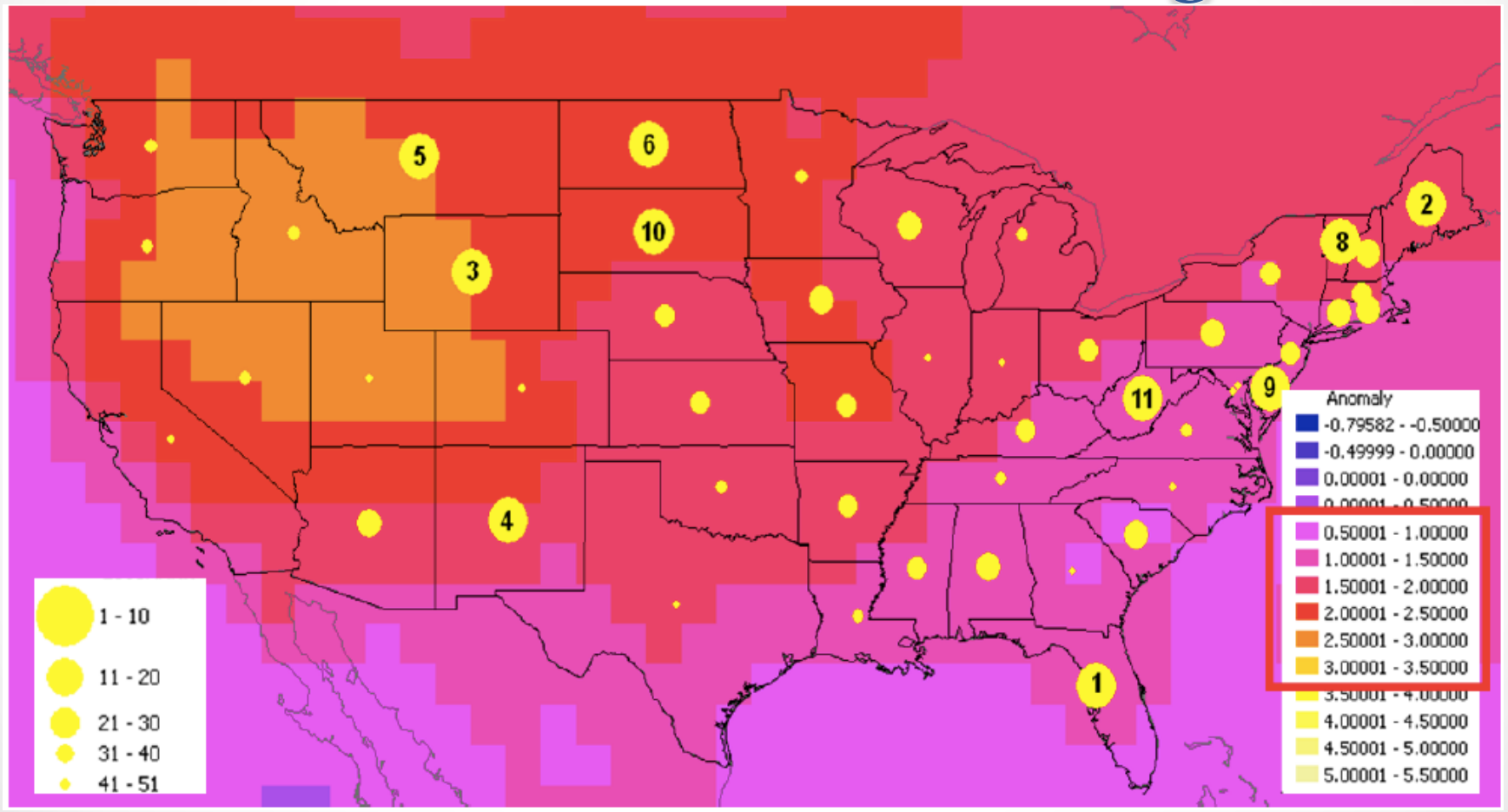
Disadvantages

- Only works on Windows
- Limited licenses – expensive software
- With large datasets, some metadata may be bad
- Results may appear more reliable than they are
- GIS may run slow when using very large datasets
- Tools for true 3D analysis not available in basic toolbox

Climate/Meteorology Uses of GIS

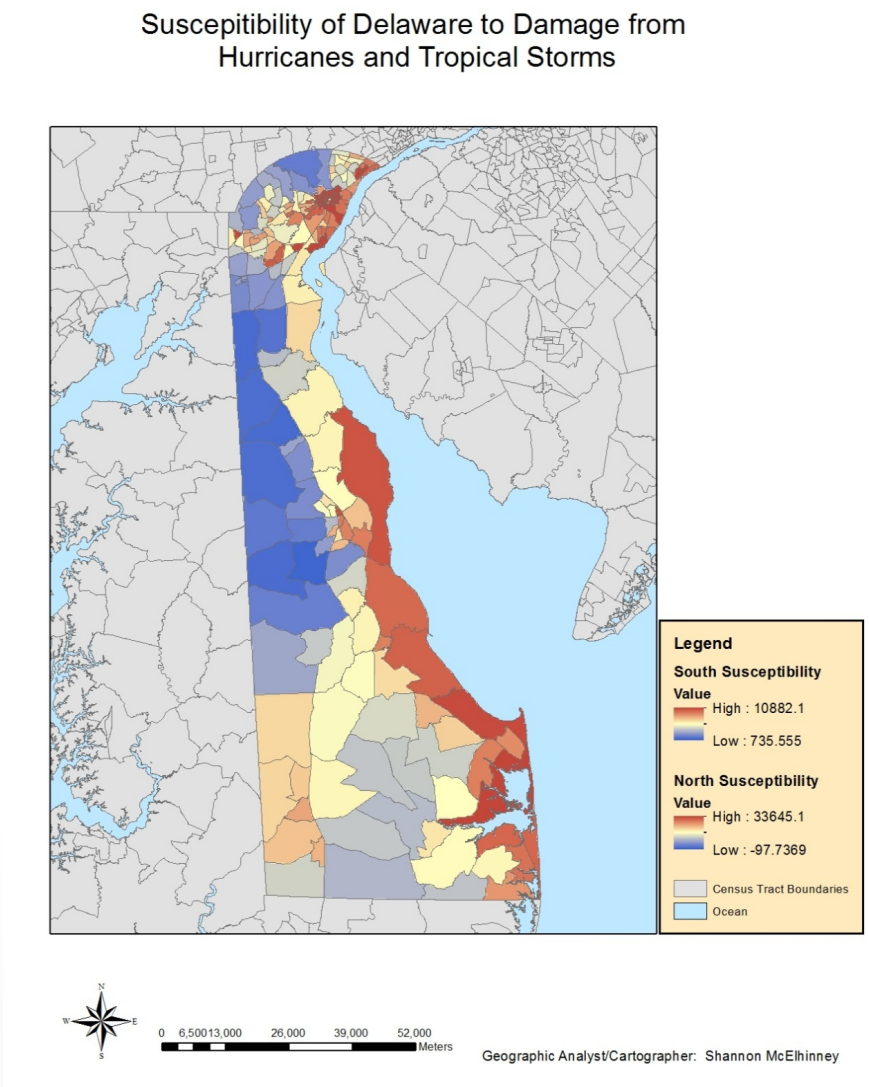
- AWIPS
- NWS River Forecast Centers
- Satellite/Remote Sensing
- Plot rawinsonde tracks
- Tracking land use/land-cover on global basis

GIS and Climate Change

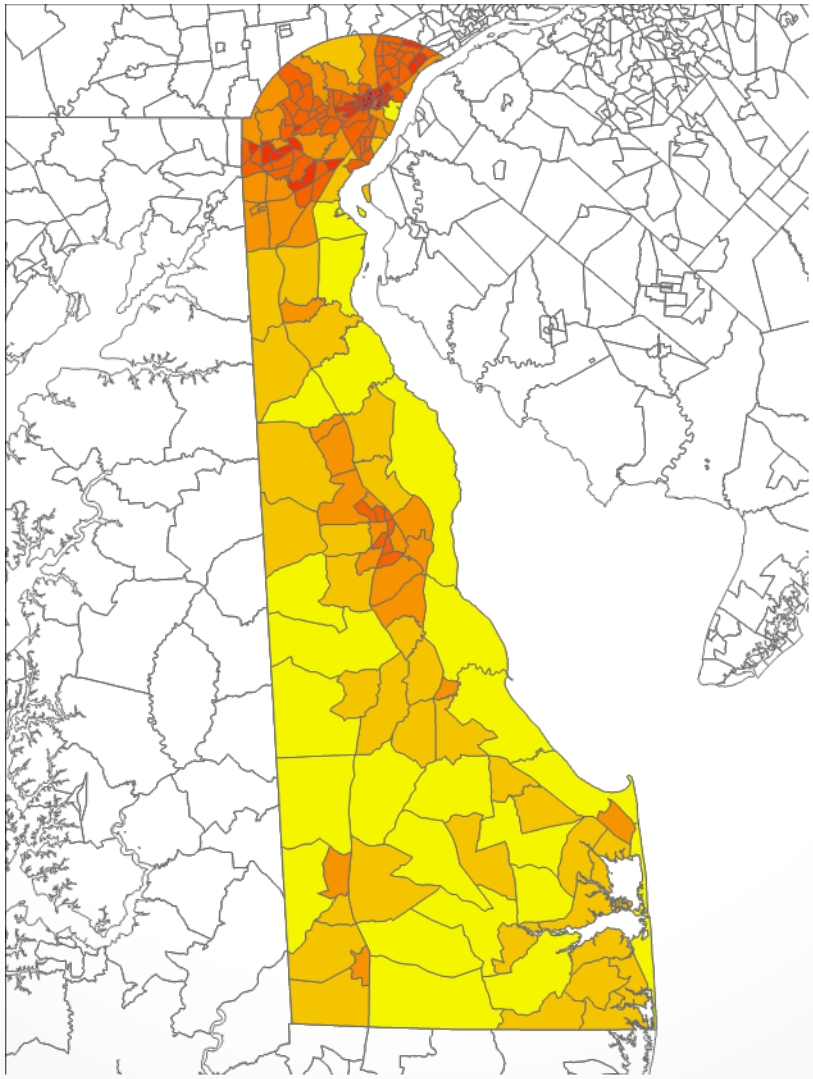


https://gisclimatechange.ucar.edu

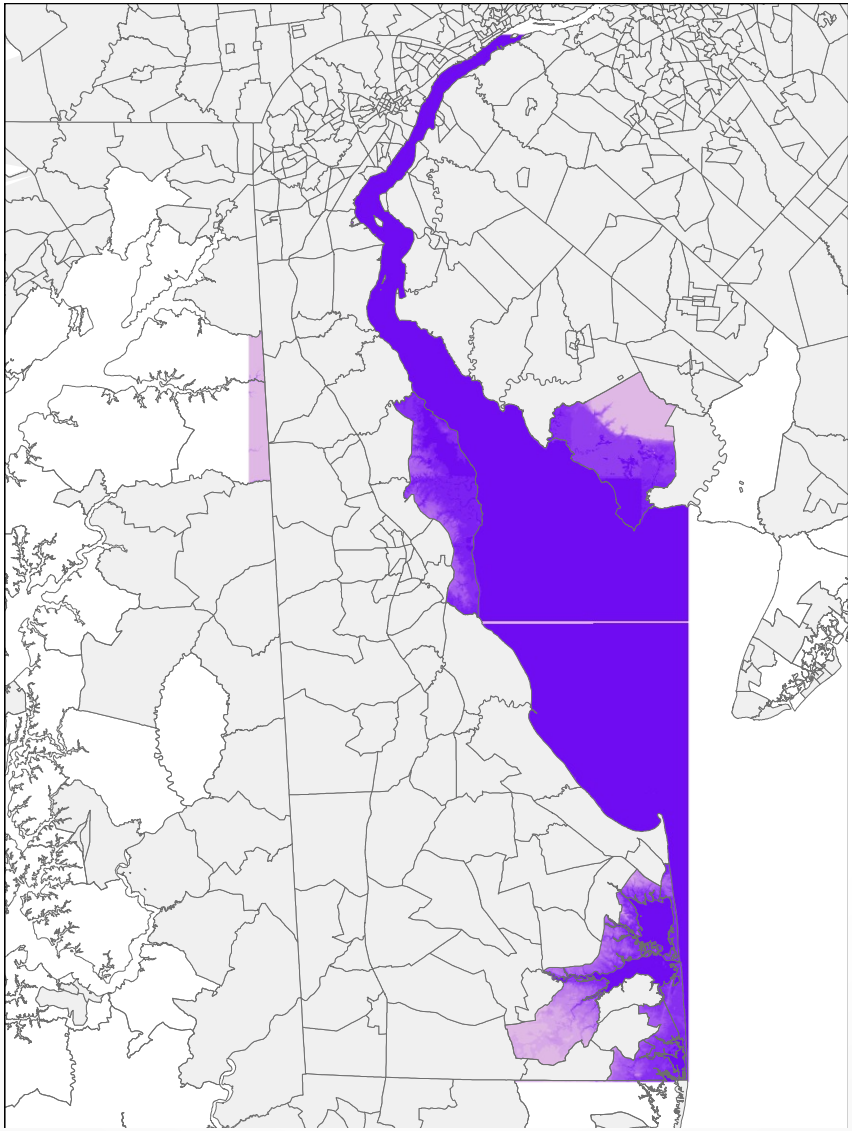
Climate/Meteorology Uses of GIS



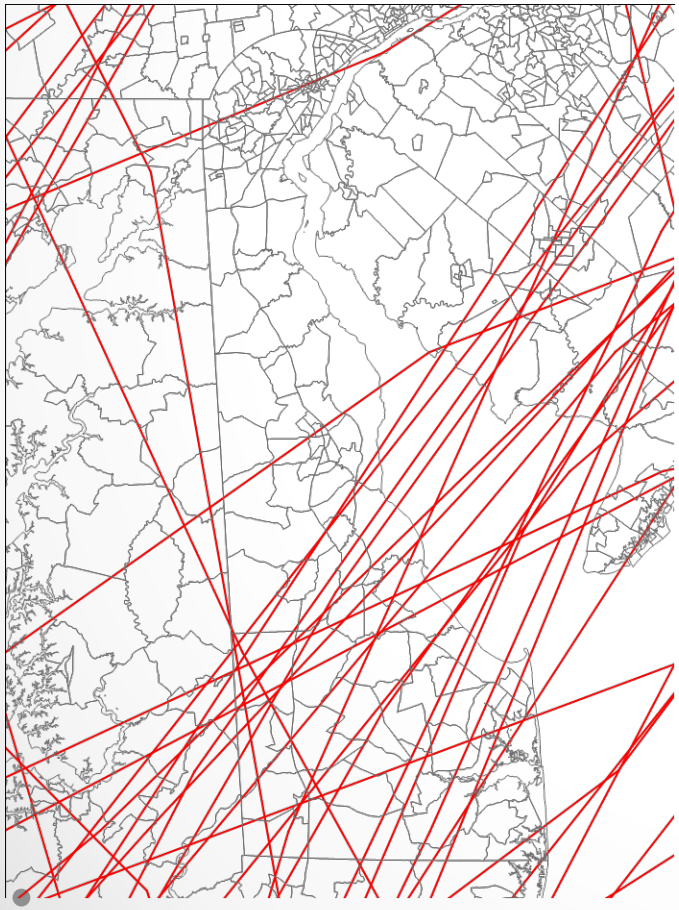
Used SQL and sorting by attribute of population per square mi in 2010



Elevation Raster- reclassified to show dark areas that are below 10m above sea level



Line density tool on storm tracks to show the spatial patterns of where storms have occurred in the past



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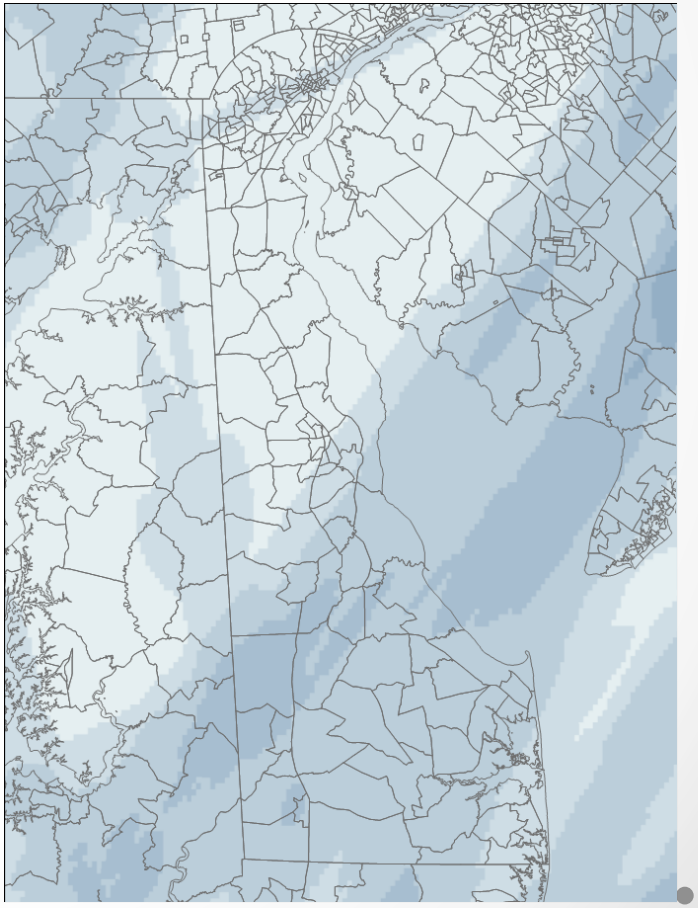
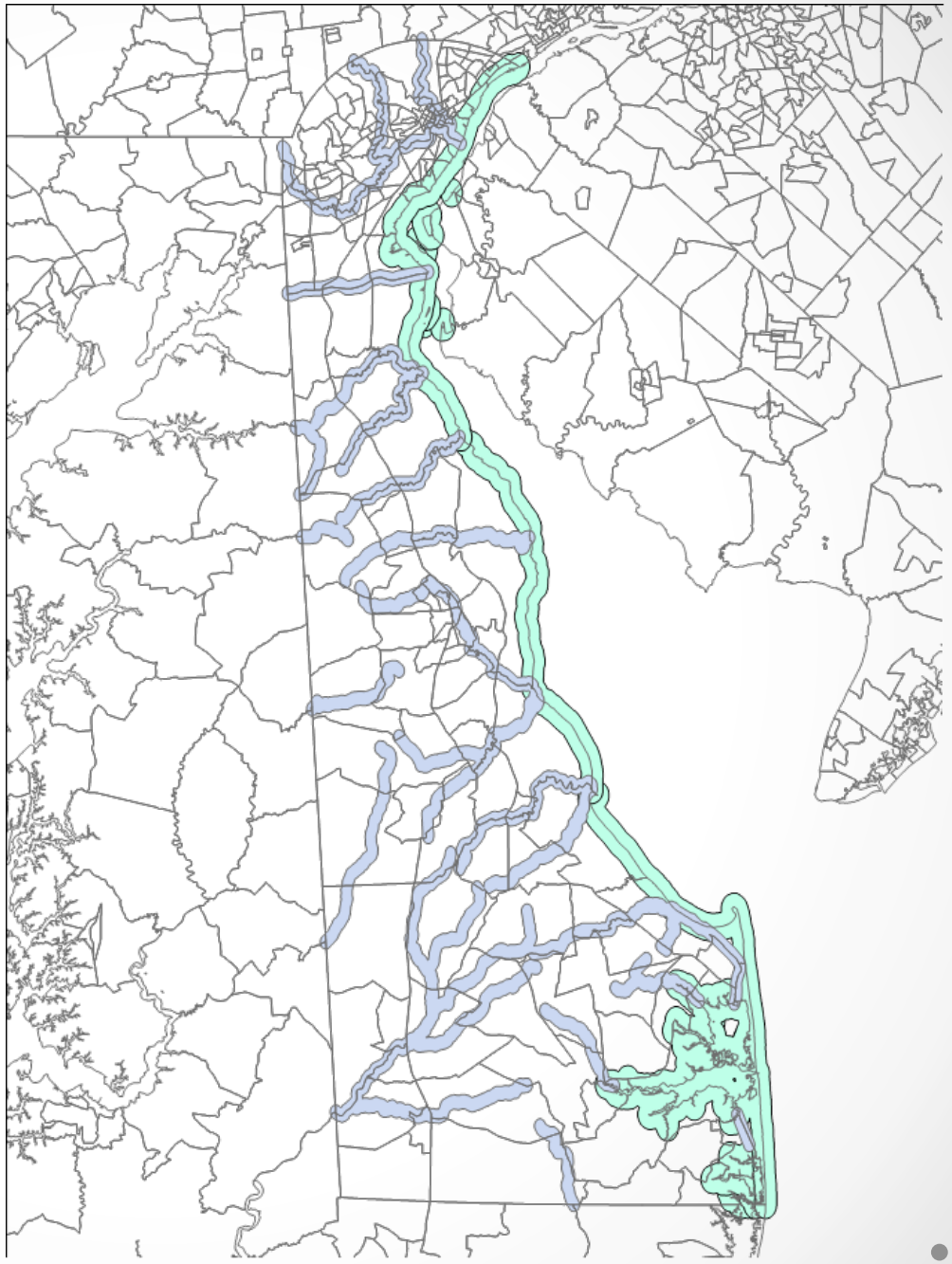
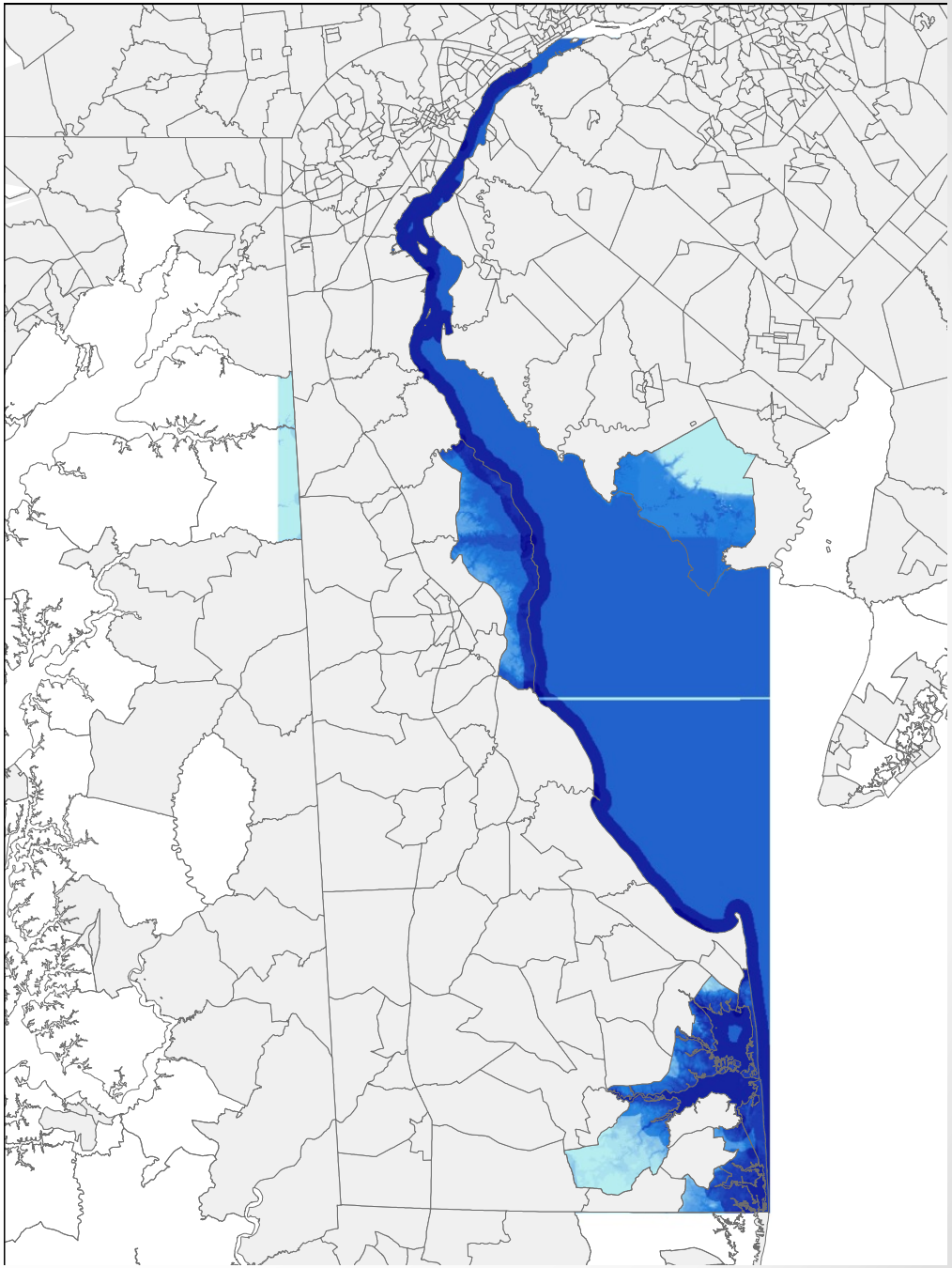


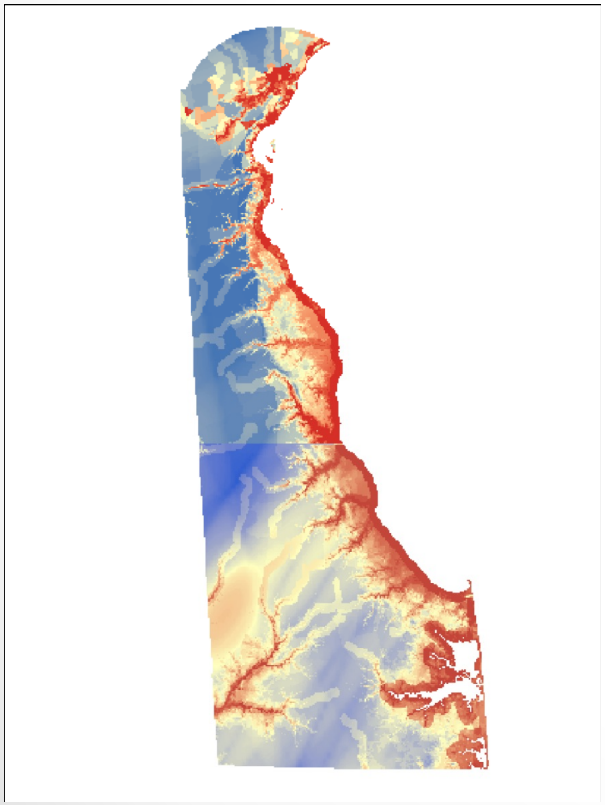
Buffer tool on river and coast layer. 1 mi radius on coast and 0.5 mi radius on rivers



Coast and Elevation Raster combined with map algebra's raster calculator. Greatest weight given to low-lying areas on coast due to storm surge.



- All Layers Added Together- red has greatest value, blue had lowest, beige is neutral
- Used the zonal statistics tool to find average of all raster cells within each census tract



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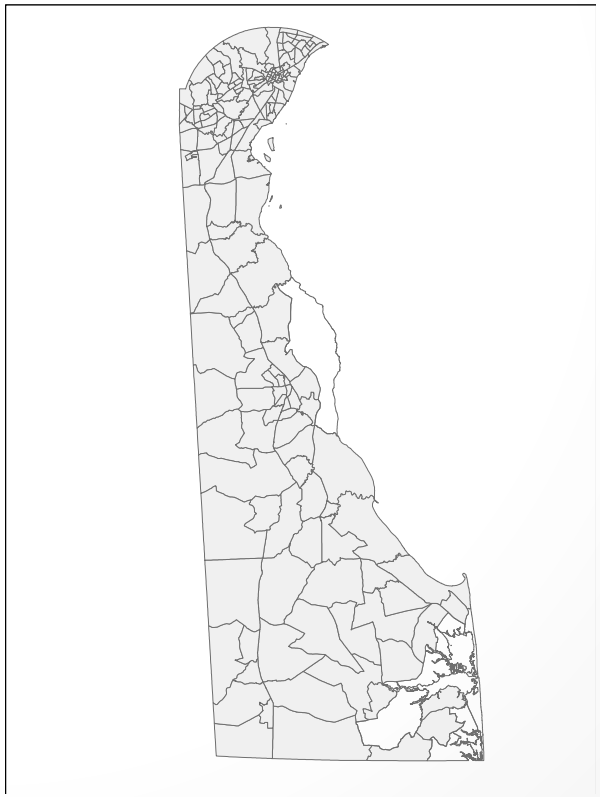

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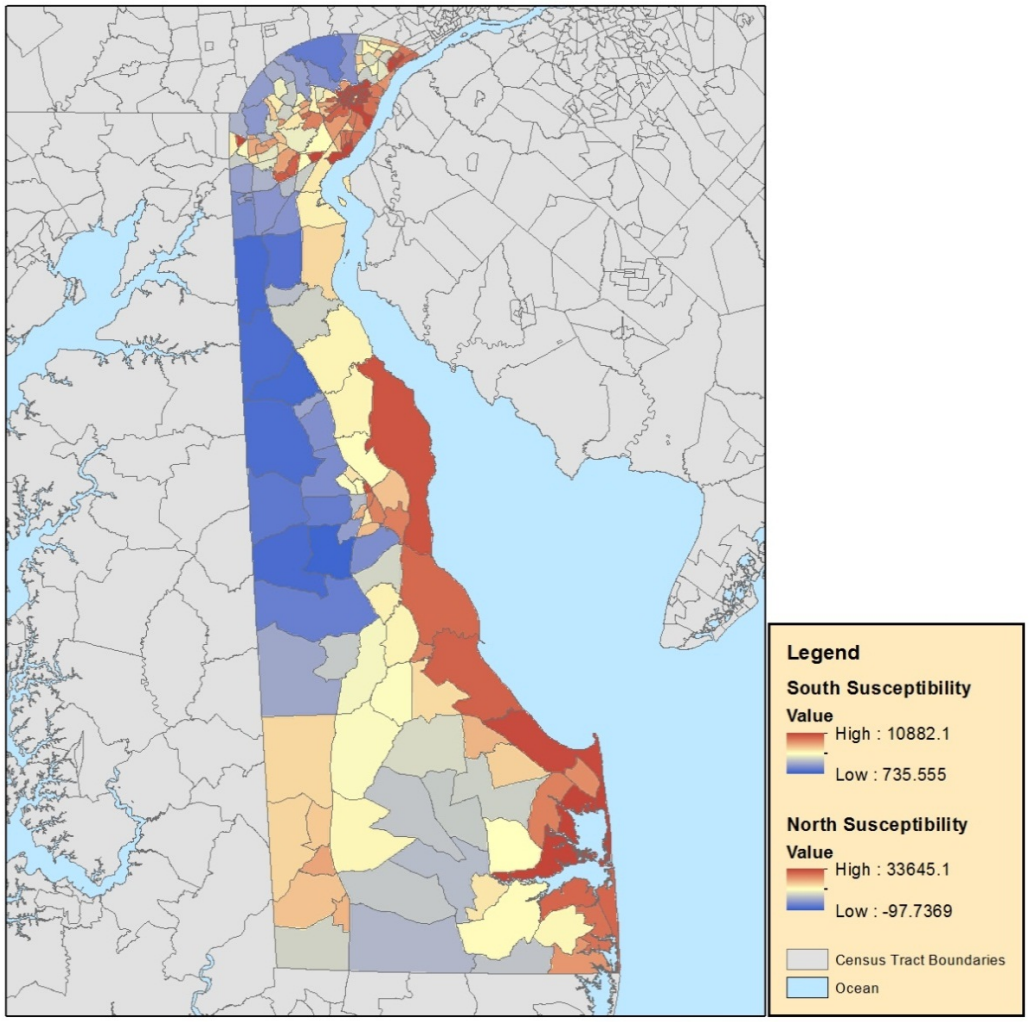
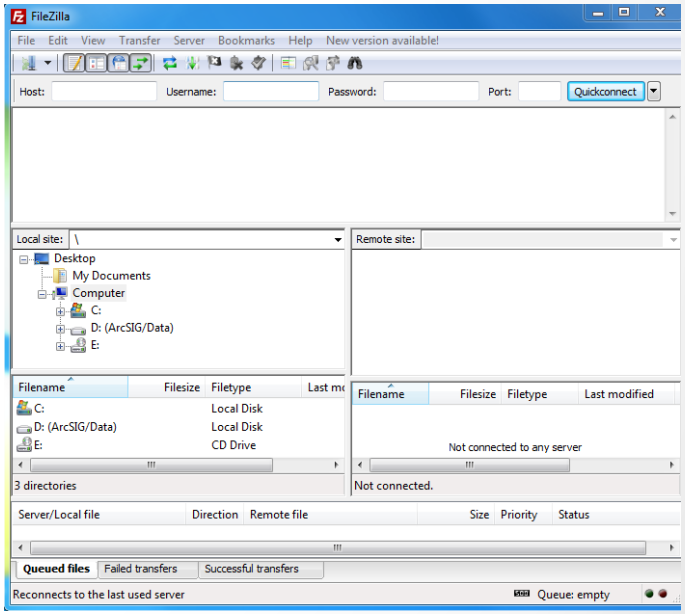
Suscepitibility of Delaware to Damage from Hurricanes and Tropical Storms



Geographic Analyst/Cartographer: Shannon McElhinney

Getting Started

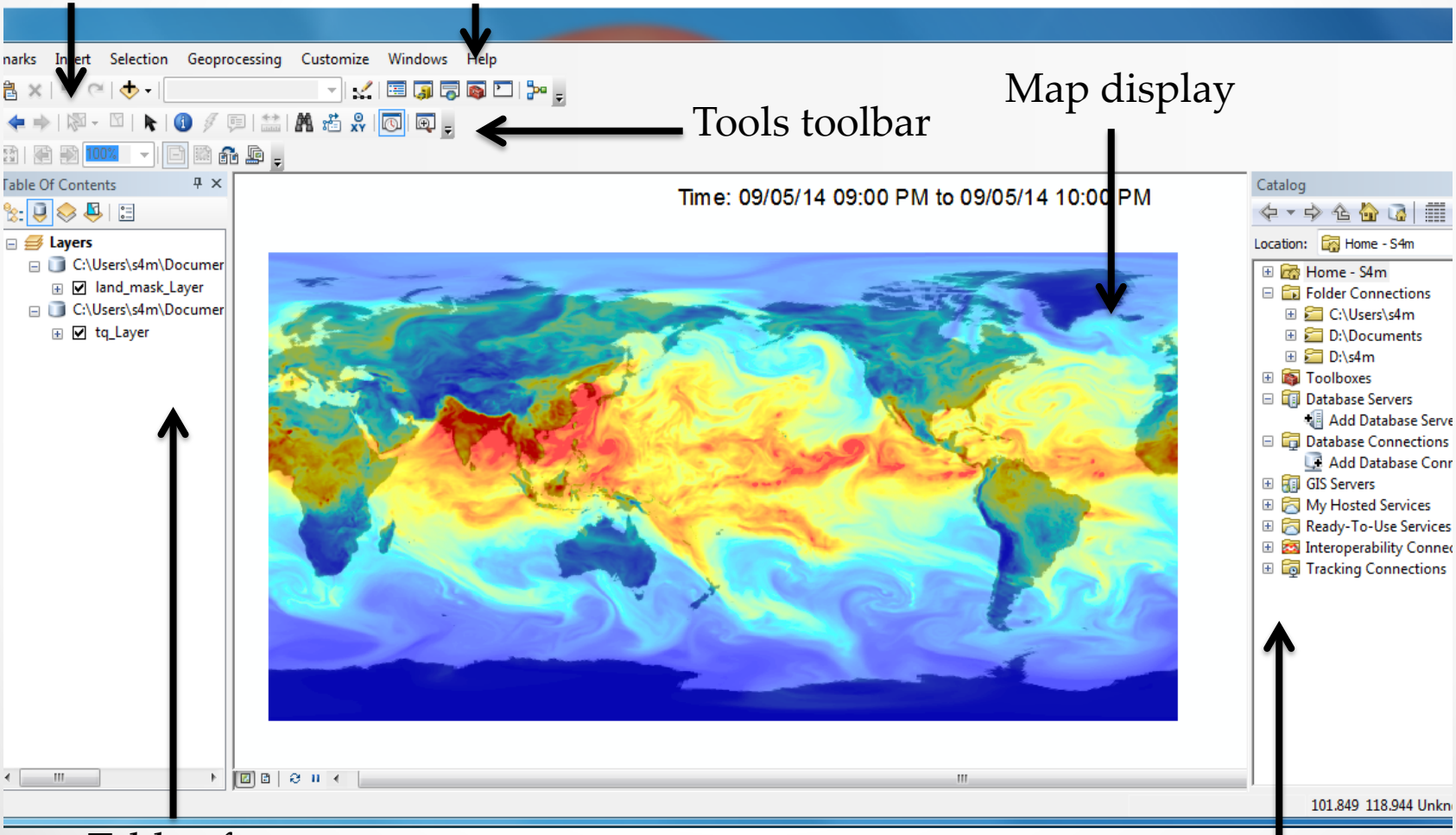
- Go to workstation (1st on left) in the Mac Lab (Rm 316)
- Switch to Windows, turn on machine, log in or use CAC
- Find ArcMap 10.2 under All Programs, ArcGIS



Connect to Workstation

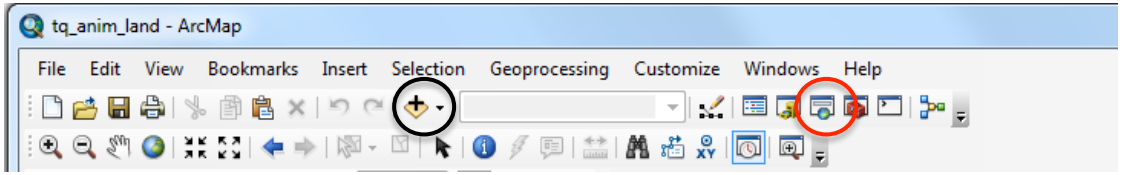
- Open filezilla
  - Host: [name of desktop].gfdl.noaa.gov
  - Username: 3 letter username
  - Password: NEMS password
  - Port: 21 for ftp, 22 for sftp
- Quickconnect
- Help: wiki.gfdl.noaa.gov/index.php/Filezilla_Tutorial

How it Works


Standard toolbar
Main menu toolbar
Tools toolbar
Map display
Table of contents
ArcCatalog
narks
Insert
Selection
Geoprocessing
Customize
Windows
Help
Table Of Contents
Layers
C:\Users\s4m\Documer
land_mask_Layer
C:\Users\s4m\Documer
tq_Layer
Time: 09/05/14 09:00 PM to 09/05/14 10:00 PM
Catalog
Location:
Home - S4m
Home - S4m
Folder Connections
C:\Users\s4m
D:\Documents
D:\s4m
Toolboxes
Database Servers
Add Database Serve
Database Connections
Add Database Conr
GIS Servers
My Hosted Services
Ready-To-Use Services
Interoperability Connec
Tracking Connections
101.849 118.944 Unkn

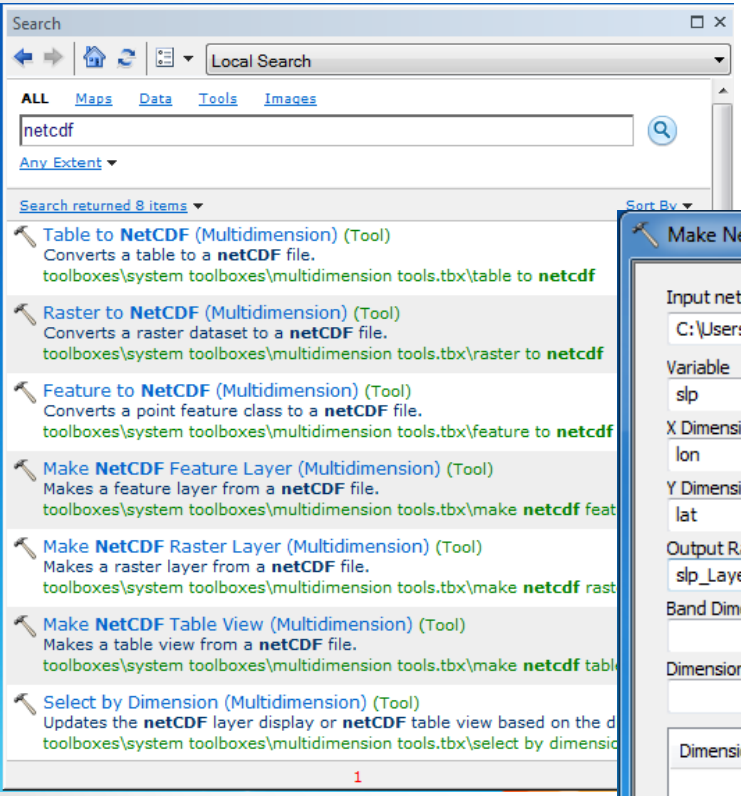
Importing Data

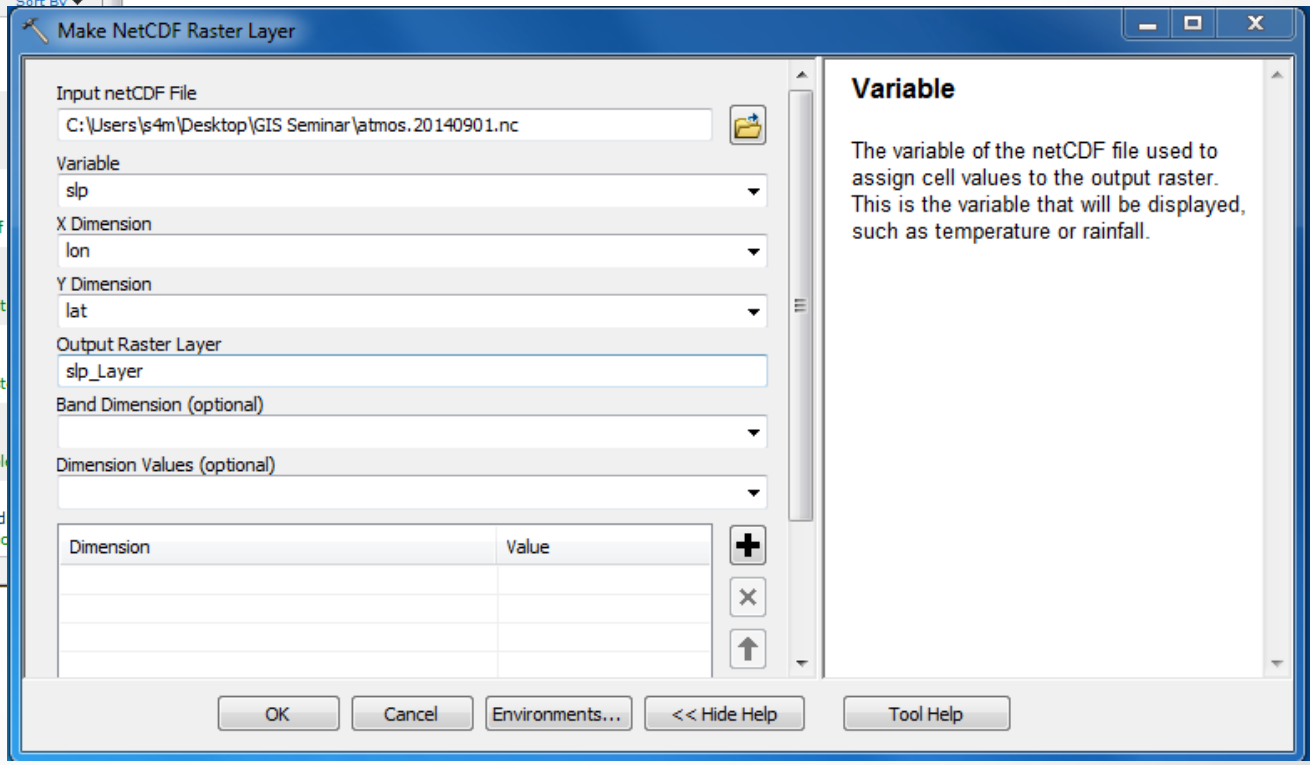
- Add data from file, basemap or data from ArcGIS Online



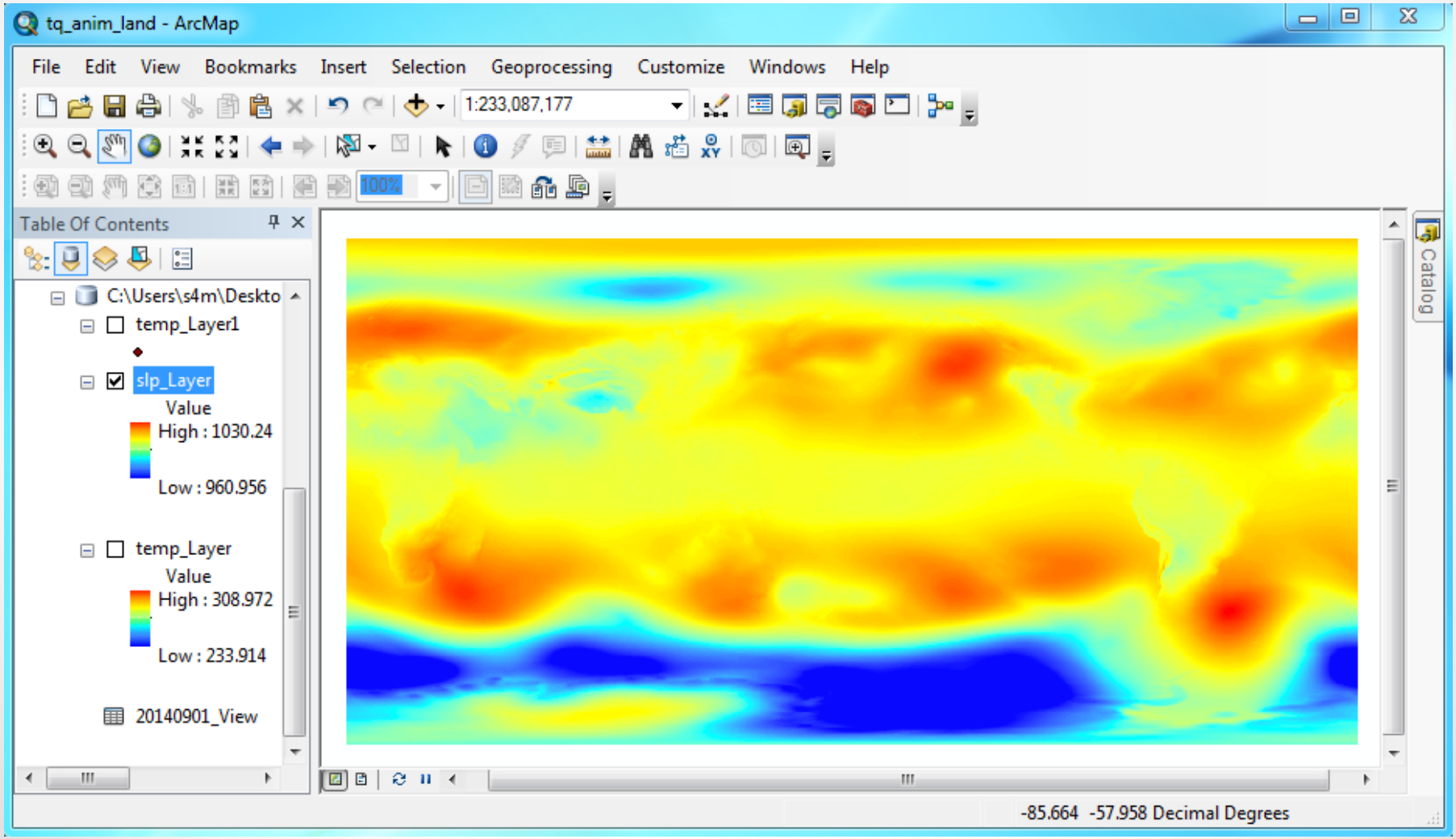
- Use tools to convert data to raster or feature layer:
  - Make NetCDF Raster Layer
  - Make NetCDF Feature Layer
  - Make NetCDF Table View

Make NetCDF Raster Layer Tool



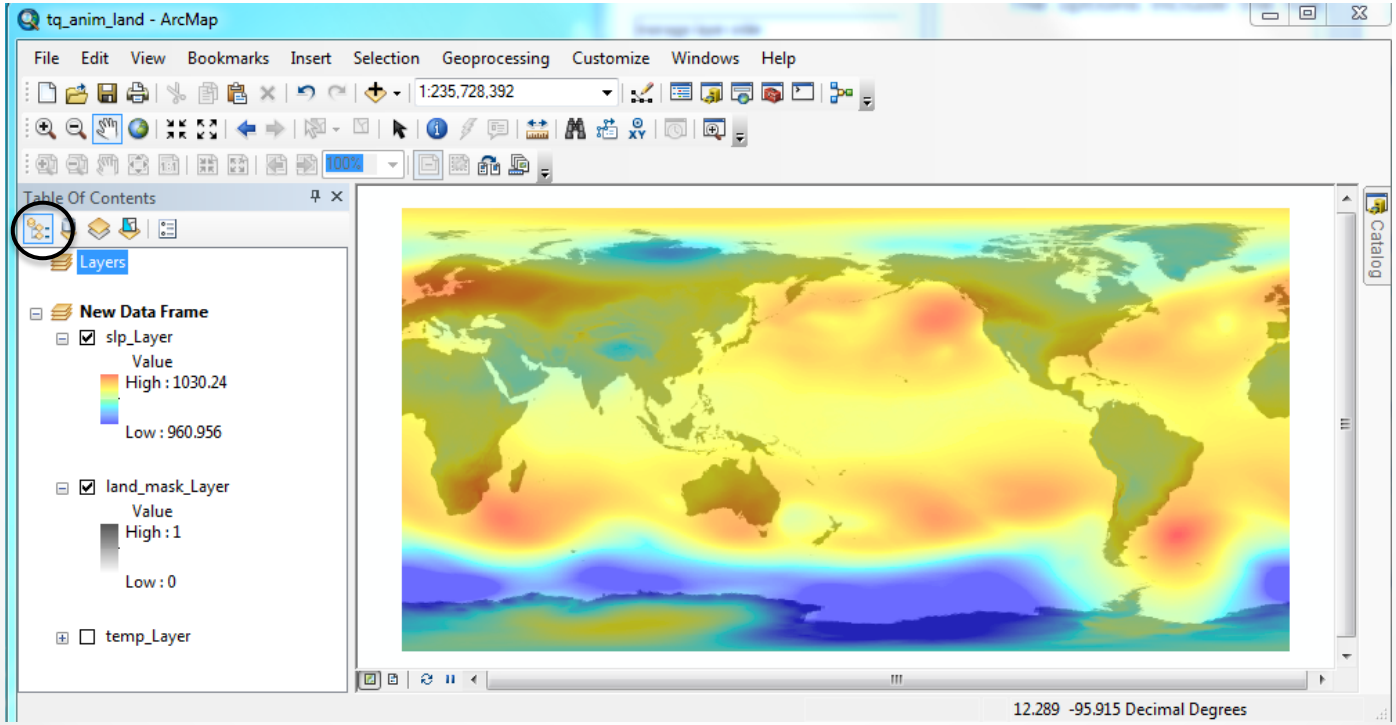


Output Raster Layer “slp_Layer”

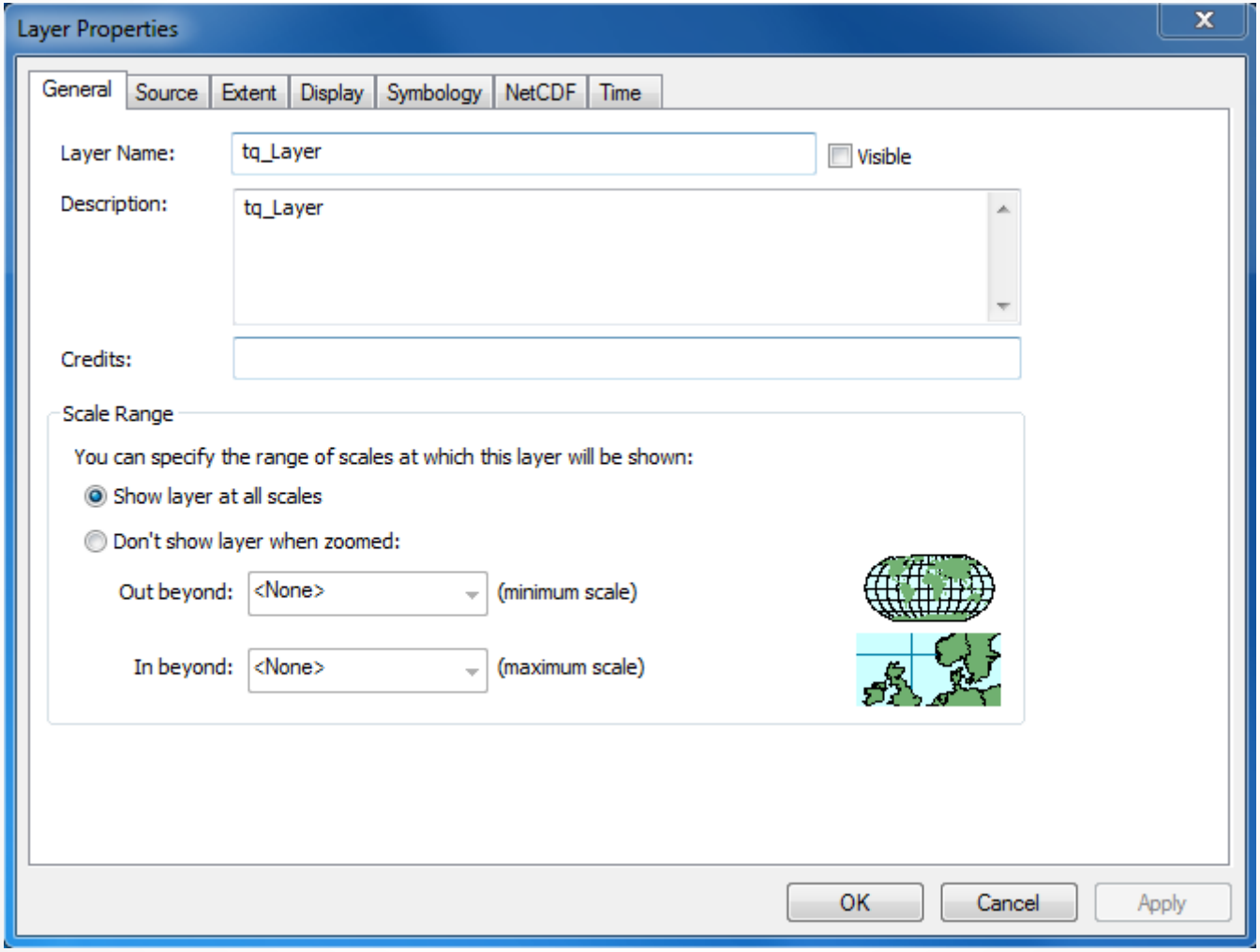


Changing Order of Layers

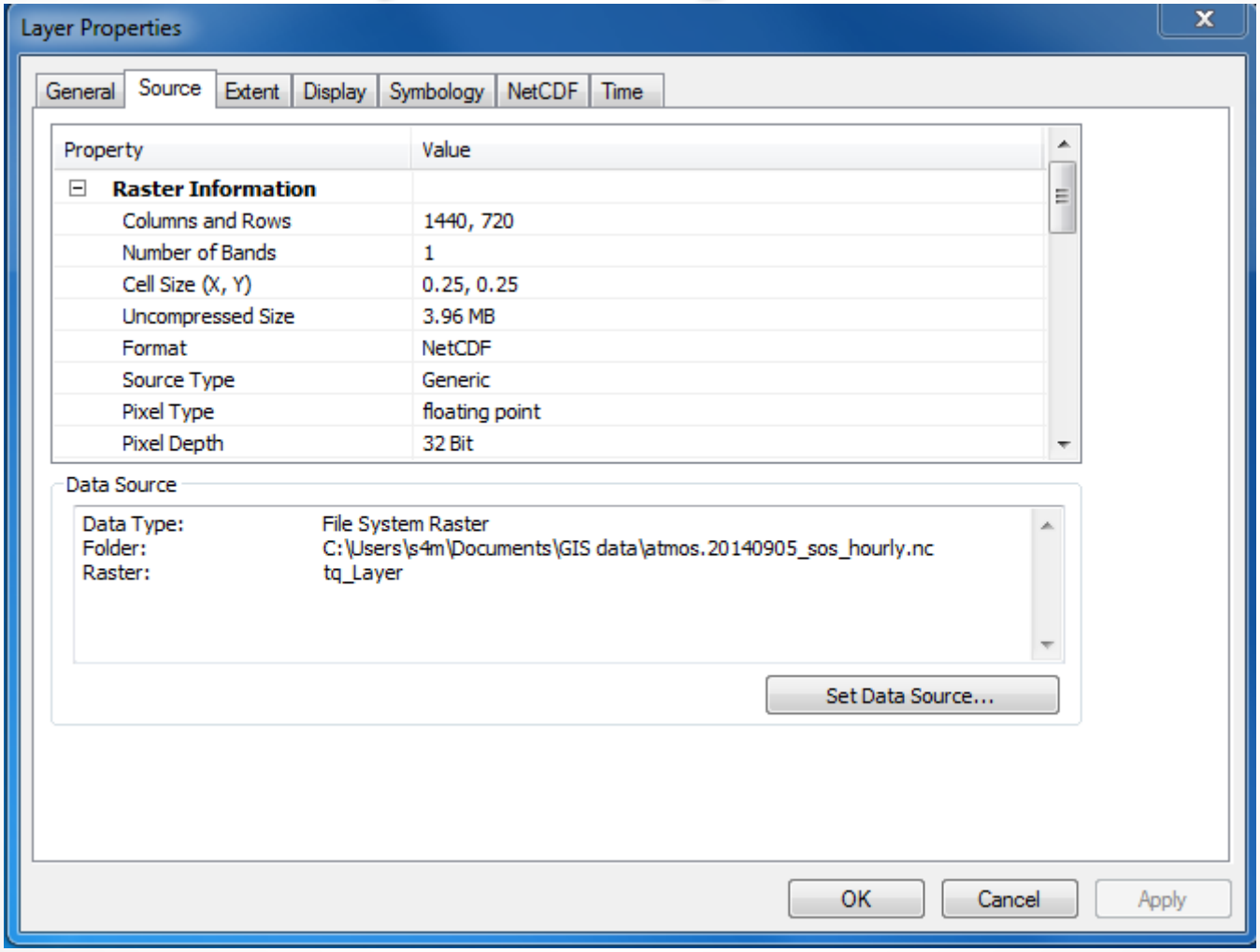
- The order of layers listed in table of contents determine the order in which they are drawn (bottom to top)
- Feature layers will always be put above raster layers
- List by drawing order, then click and drag



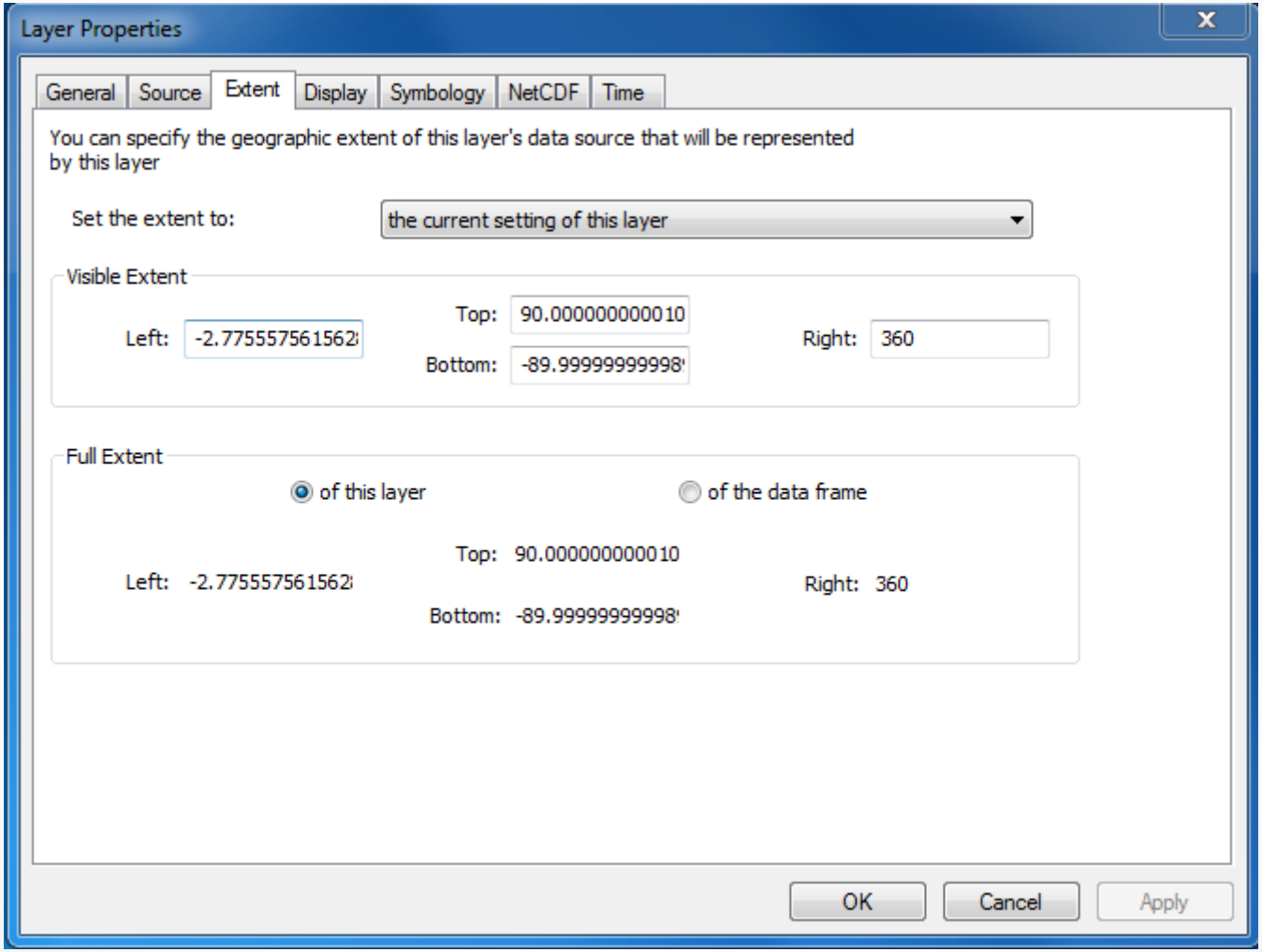
Layer Properties



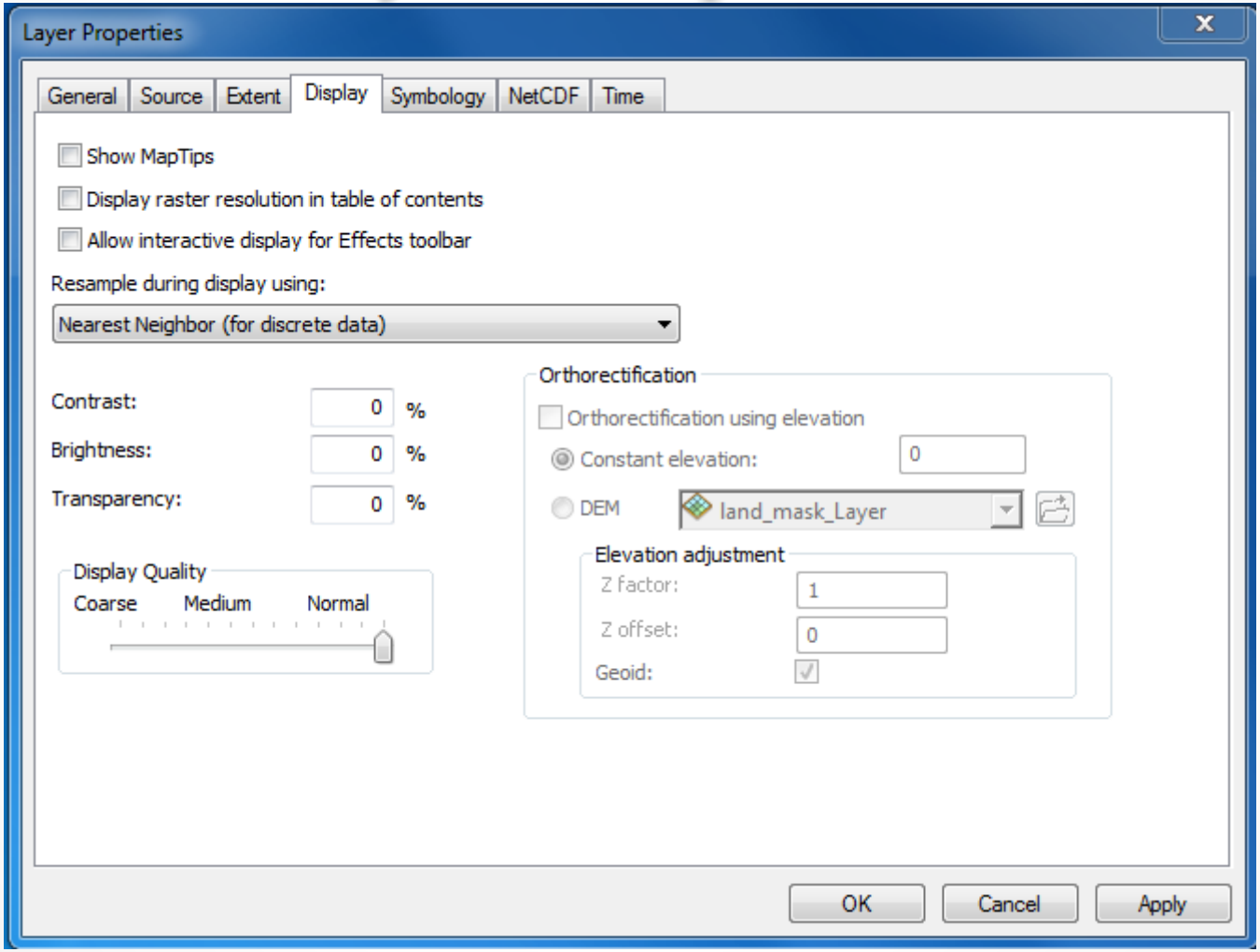
Layer Properties



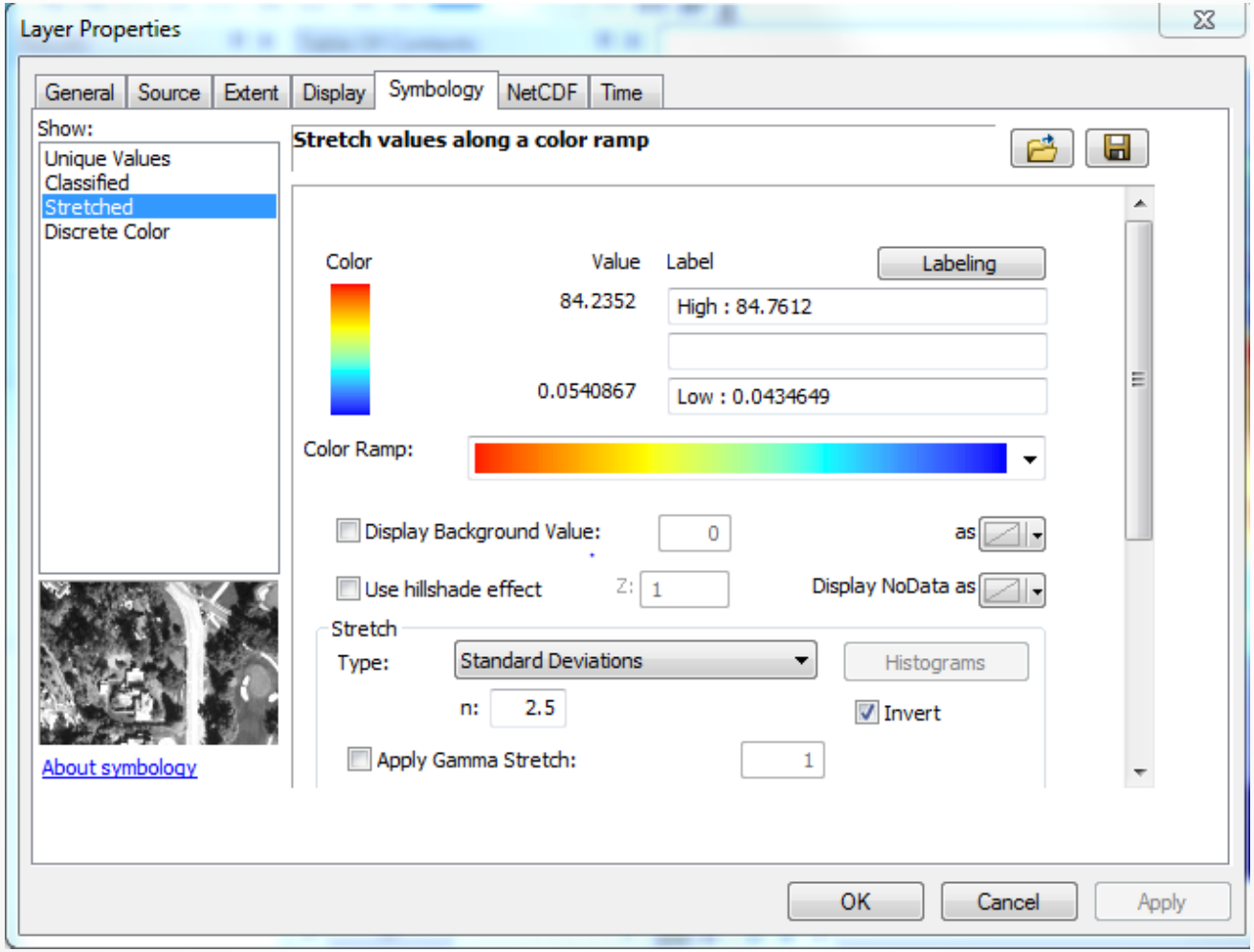
Layer Properties



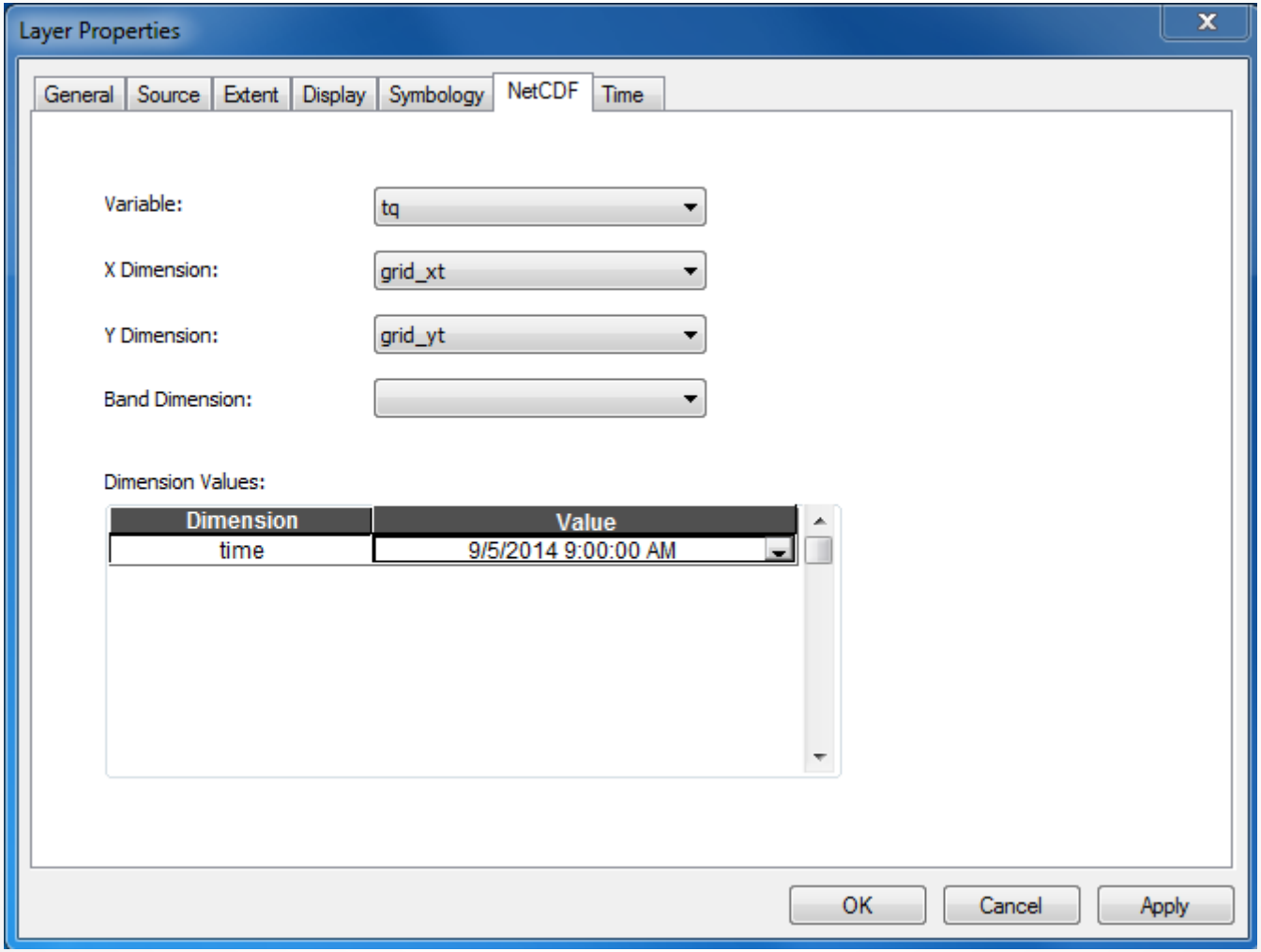
Layer Properties



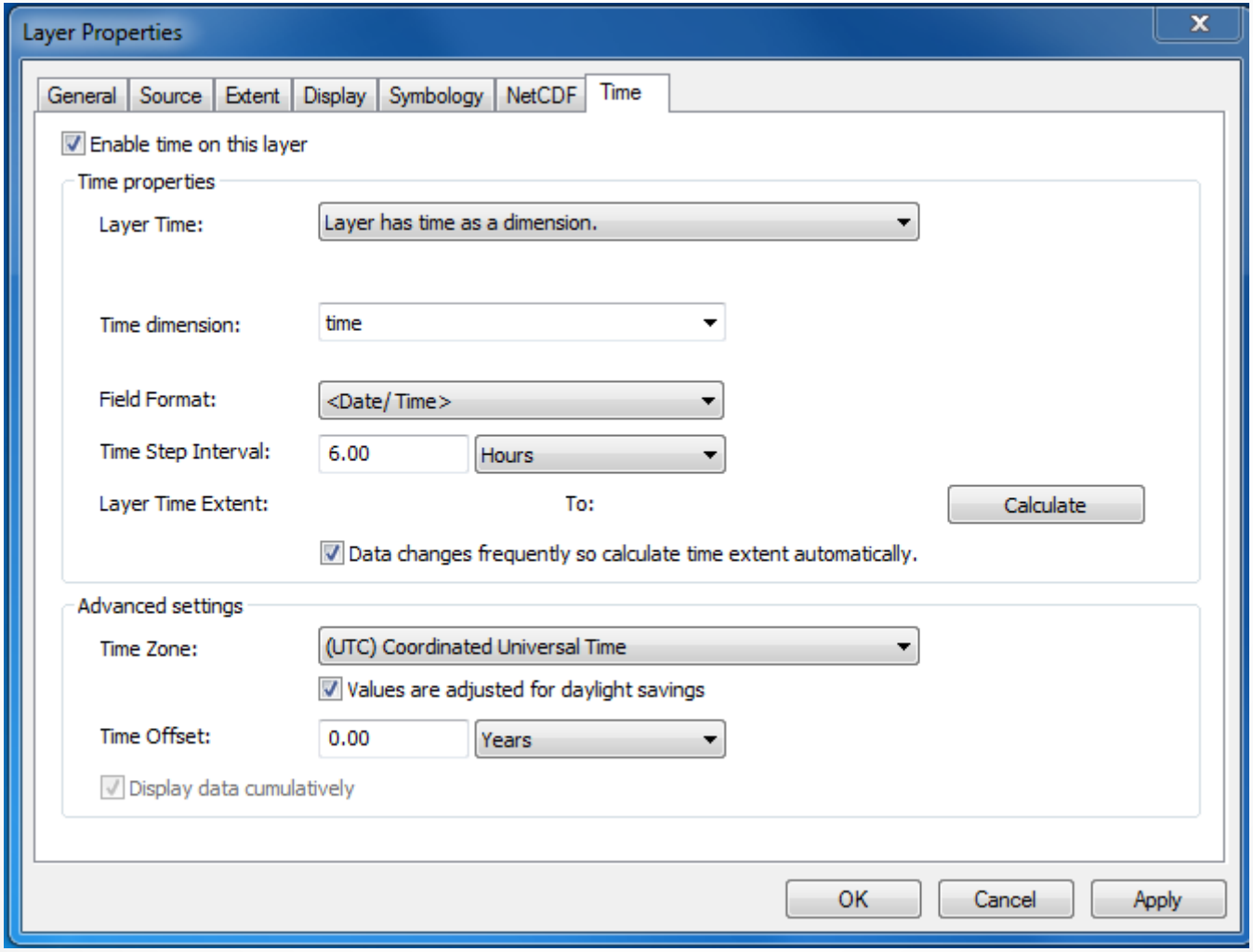
Layer Properties



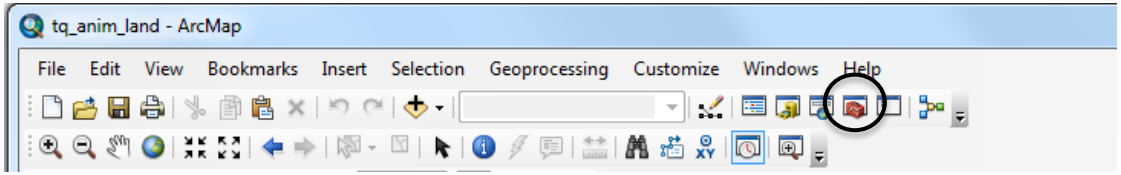
Layer Properties



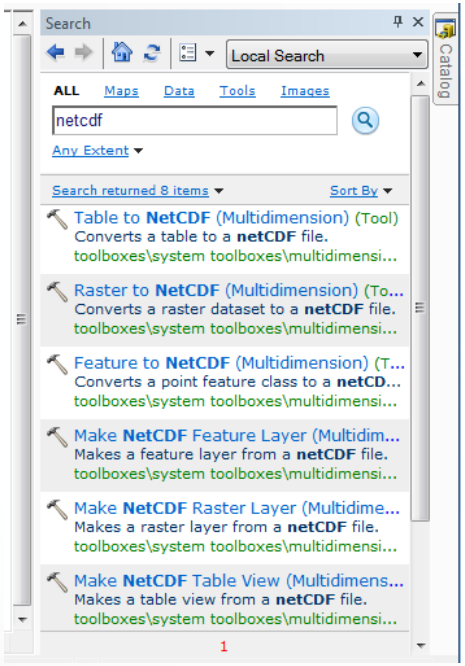
Layer Properties

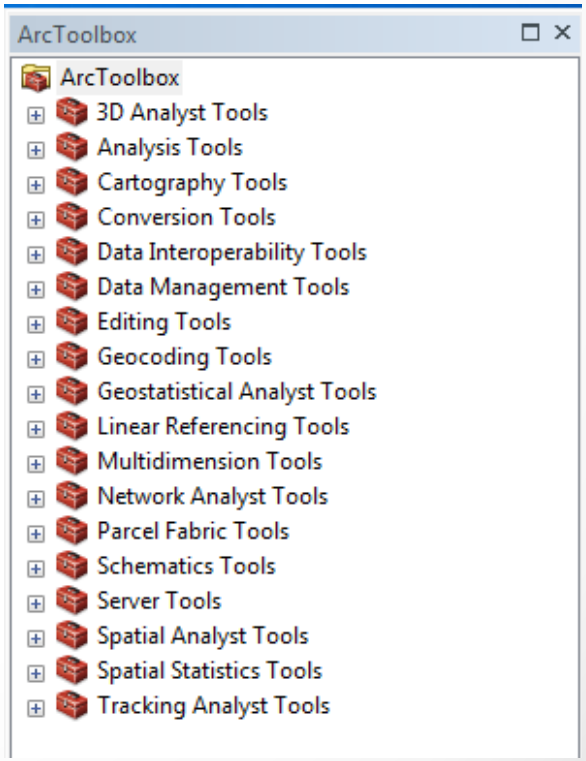


ArcToolbox



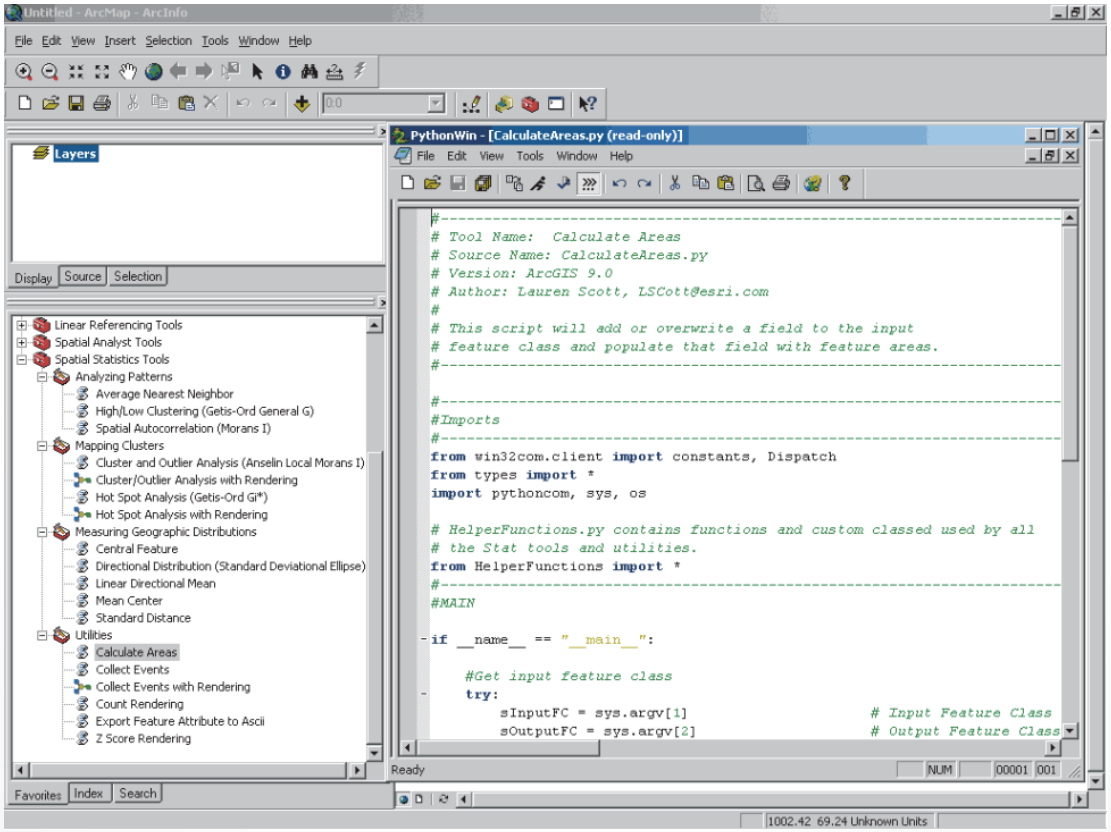
Look through the toolbox by section or search specific tools (750+)



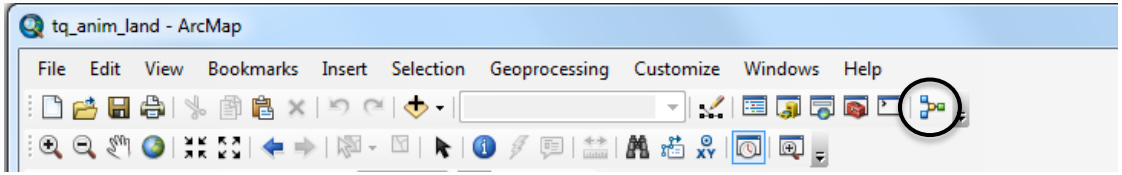


Custom Tools

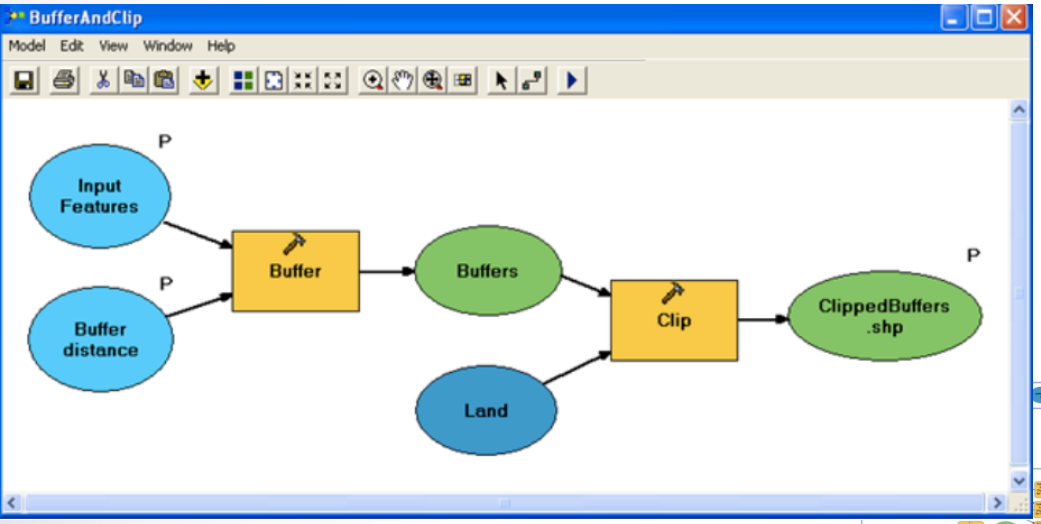
- Script tools: Python, IDE (Integrated Development Environment)

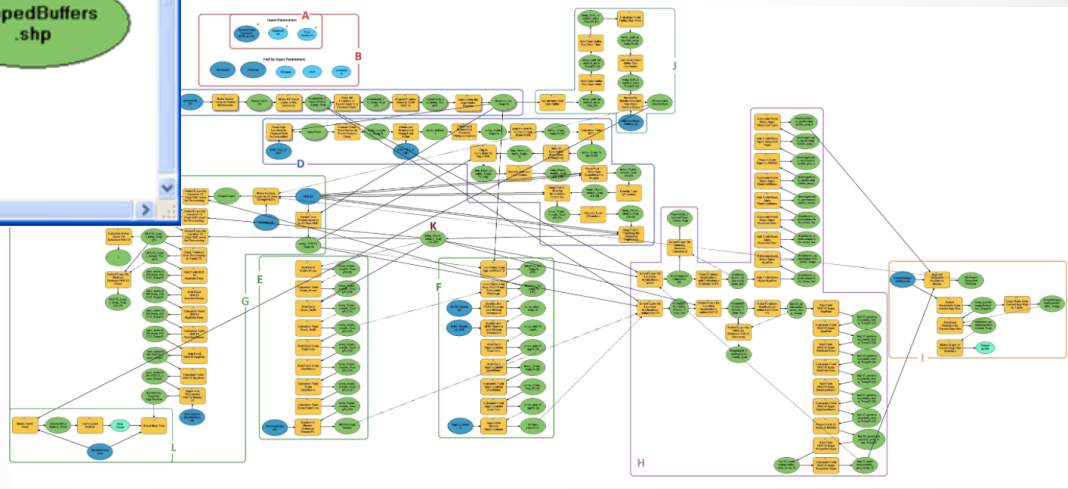


Custom Tools

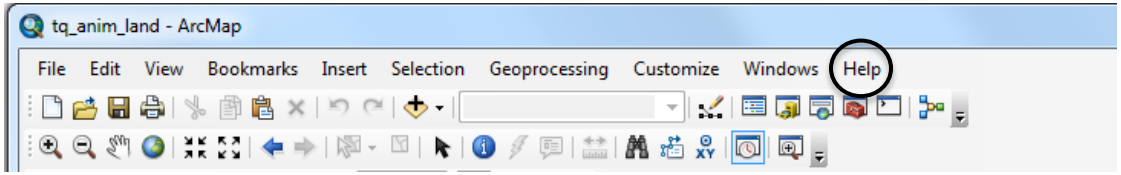


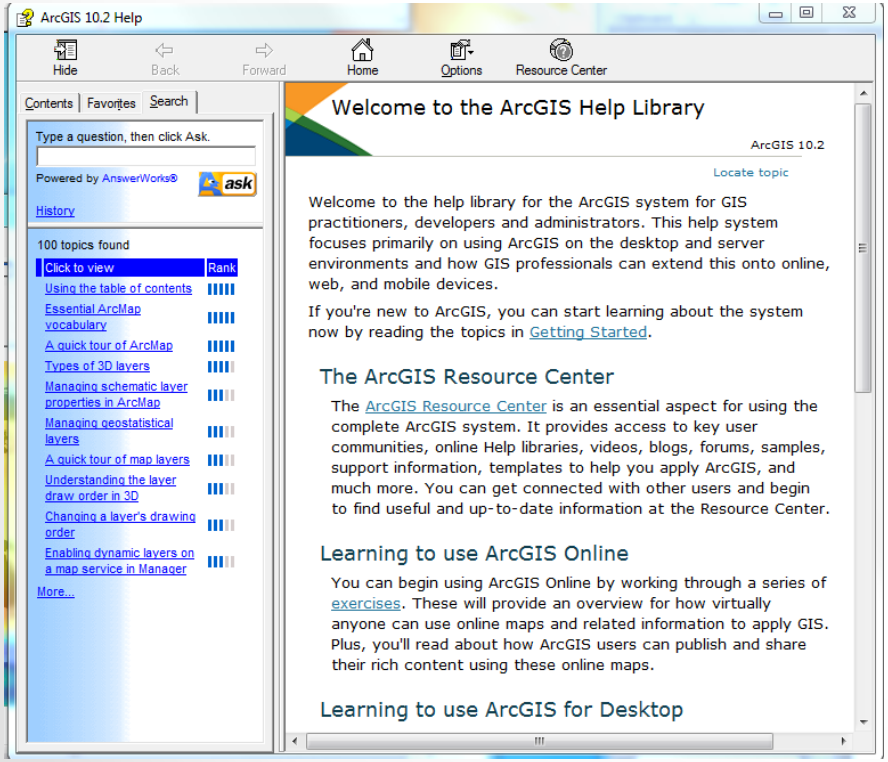
Model tools: ModelBuilder – visual programming





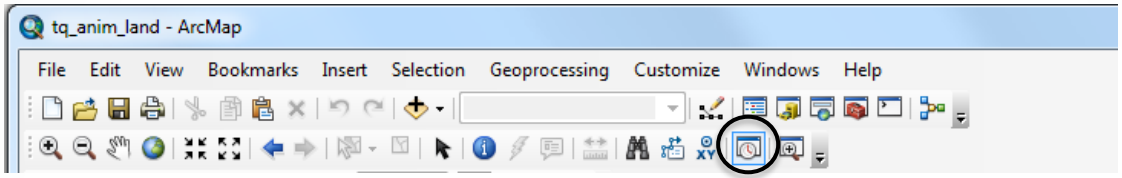
Getting Help





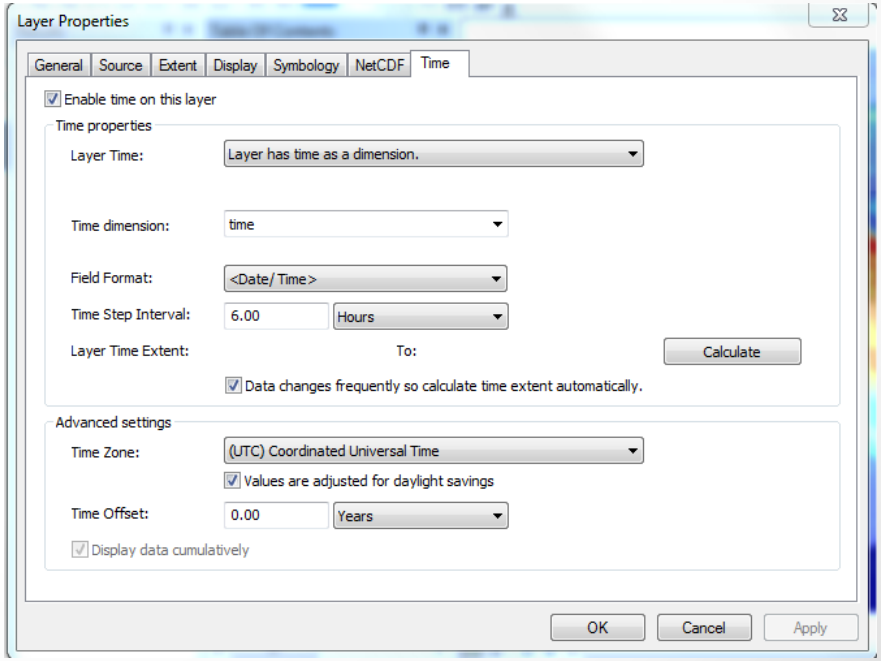
- ArcGIS Desktop Help
- ArcGIS Resource Center
  - Library has many free tutorials
- GeoNet Forum – Q&A
- What if it crashes?

Case 1: Time Slider

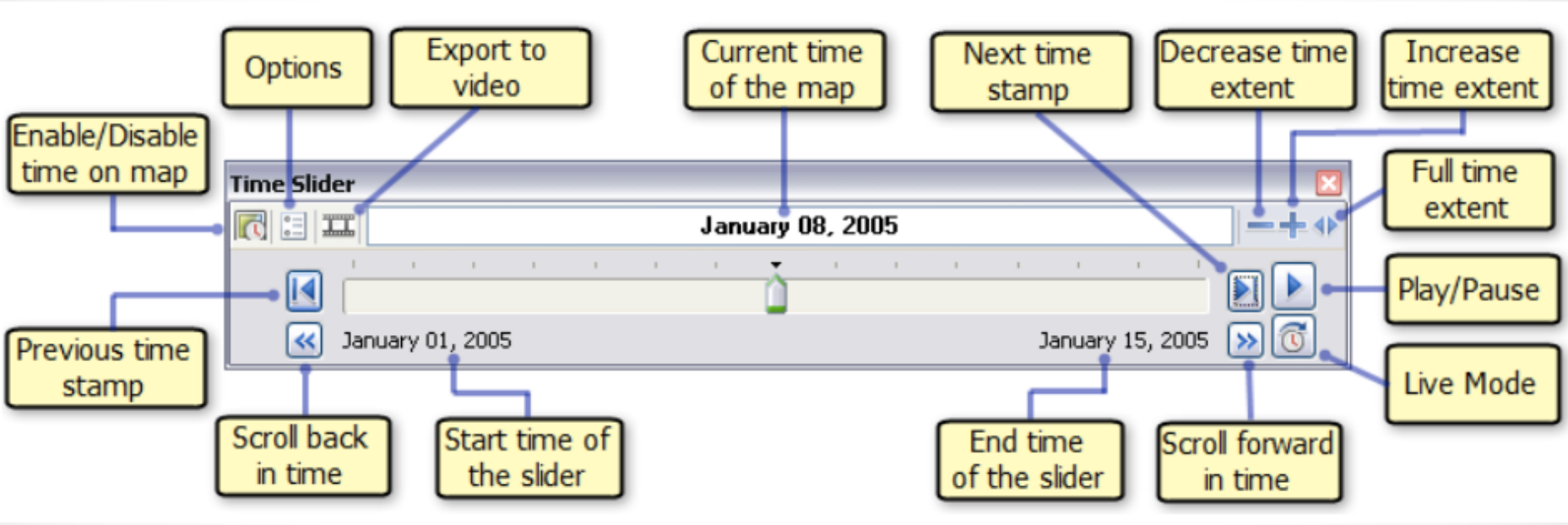


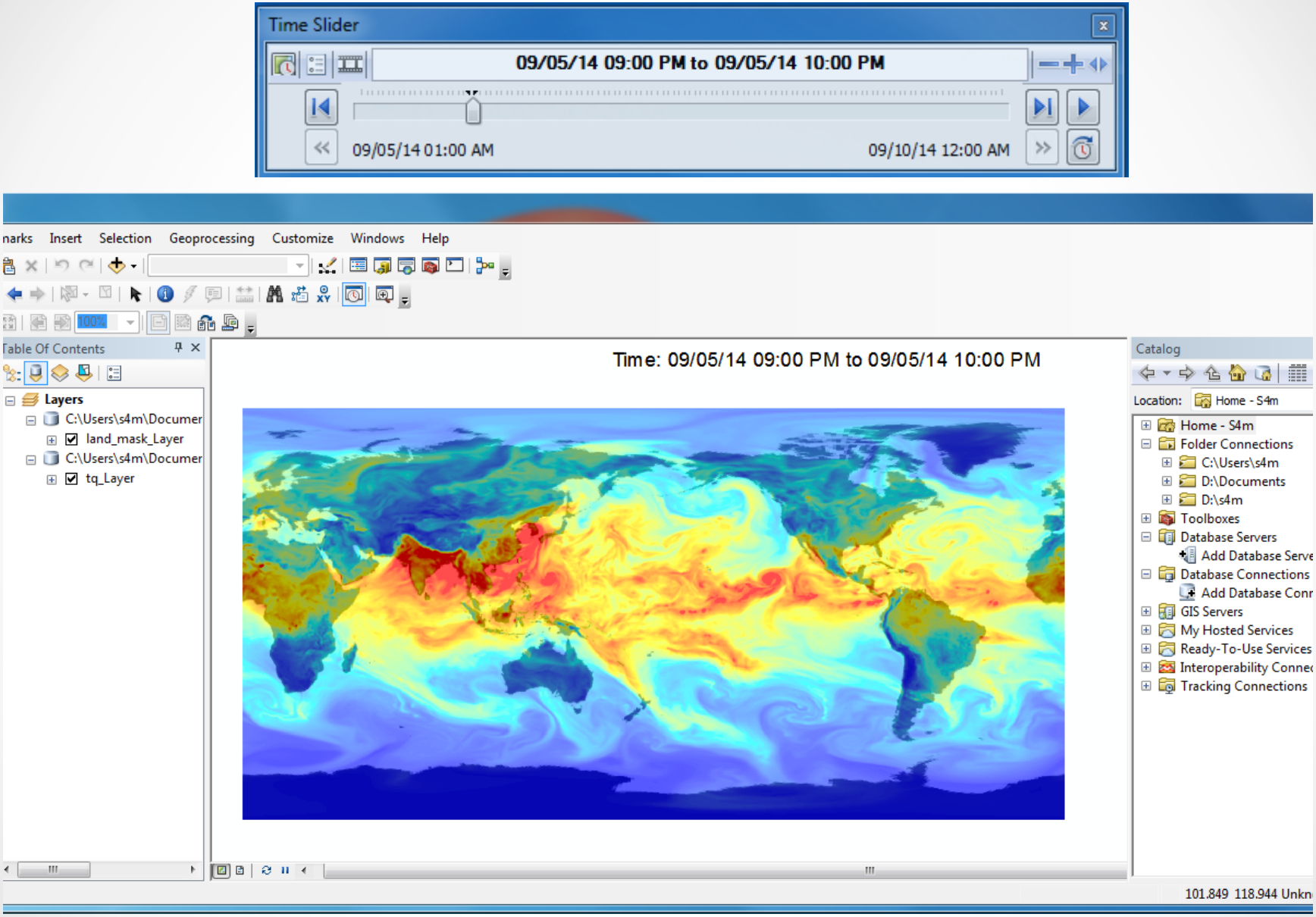
- Animations
  - Time Slider – simply visualize a temporal dataset
  - Time Animation - add other animated effects while visualizing your temporal data

- Only first time step will be shown in map view
- Must enable time for the layer

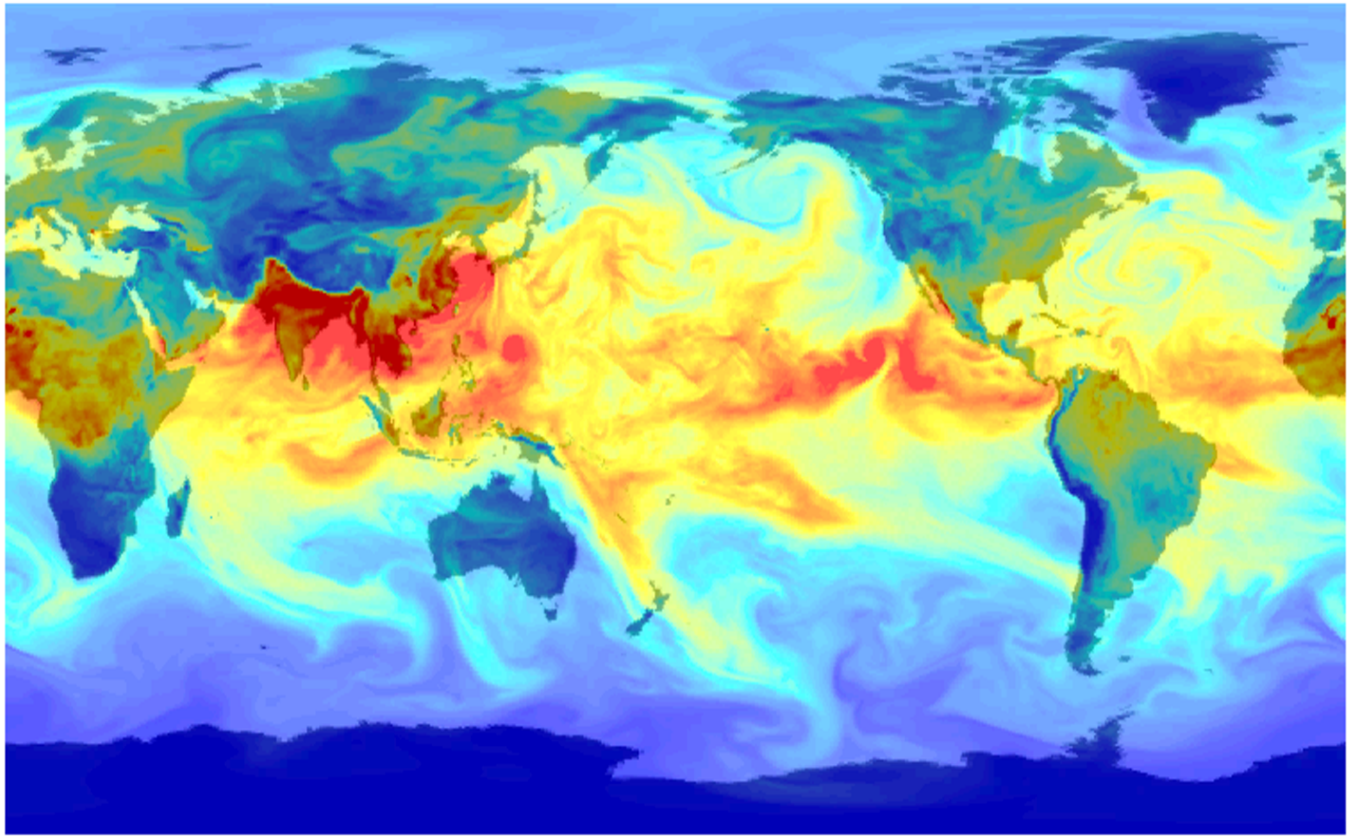


Time Slider Toolbar

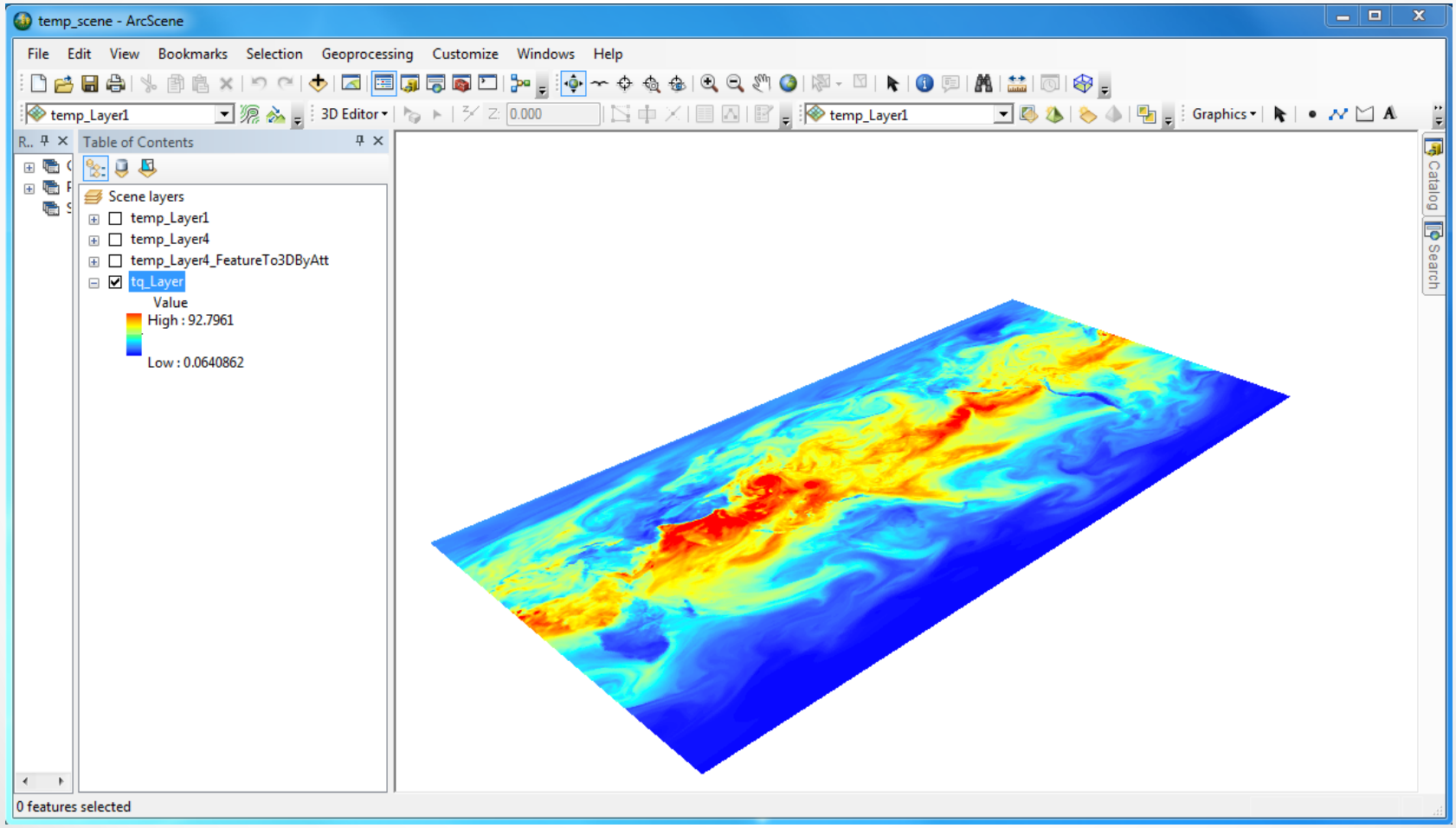



Time Slider
09/05/14 09:00 PM to 09/05/14 10:00 PM
09/05/14 01:00 AM
09/10/14 12:00 AM
narks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
C:\Users\s4m\Documer
land_mask_Layer
C:\Users\s4m\Documer
tq_Layer
Time: 09/05/14 09:00 PM to 09/05/14 10:00 PM
Catalog
Location: Home - S4m
Home - S4m
Folder Connections
C:\Users\s4m
D:\Documents
D:\s4m
Toolboxes
Database Servers
Add Database Serve
Database Connections
Add Database Conr
GIS Servers
My Hosted Services
Ready-To-Use Services
Interoperability Connec
Tracking Connections
101.849 118.944 Unkn

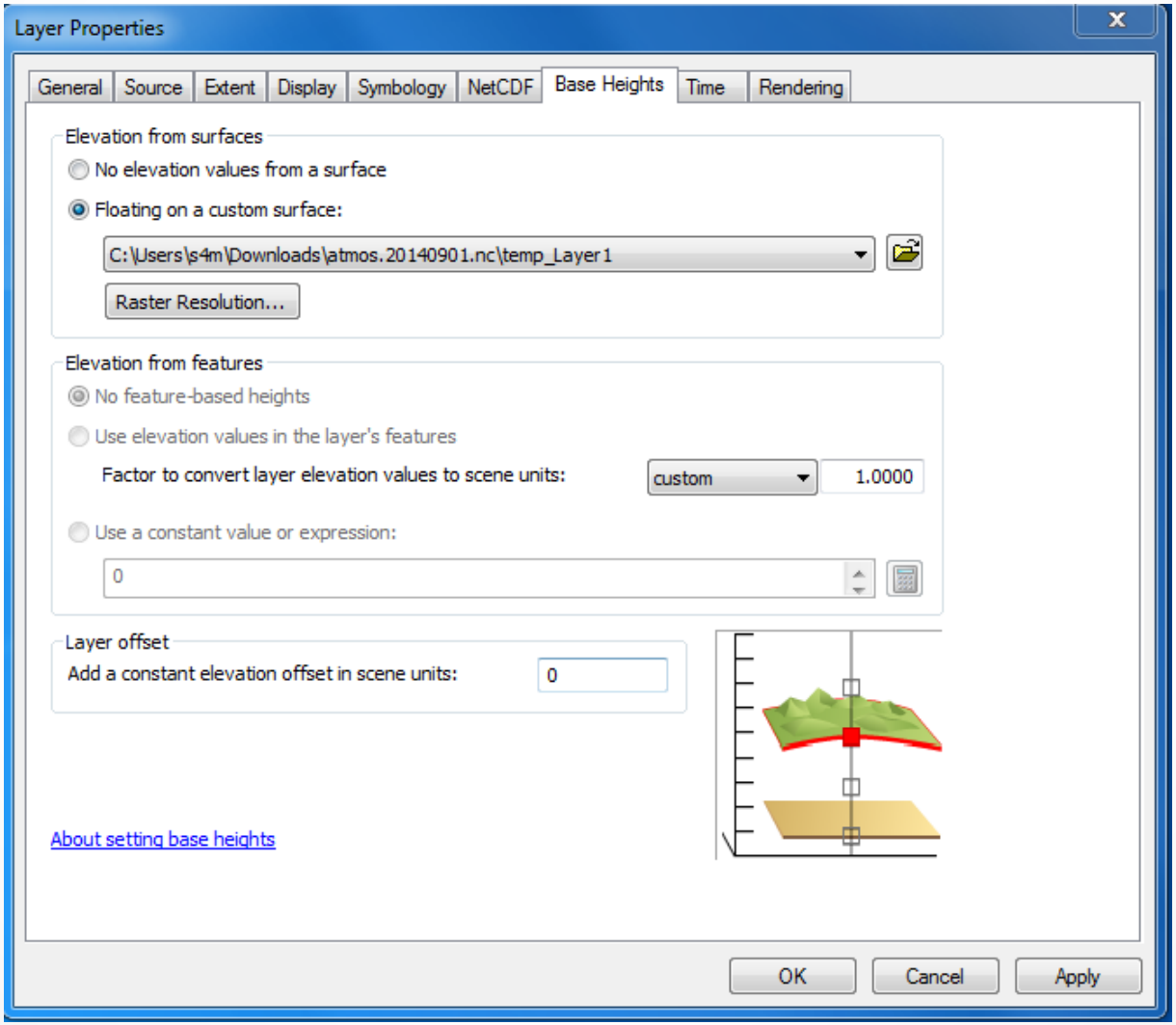
Total Precipitable Water Path



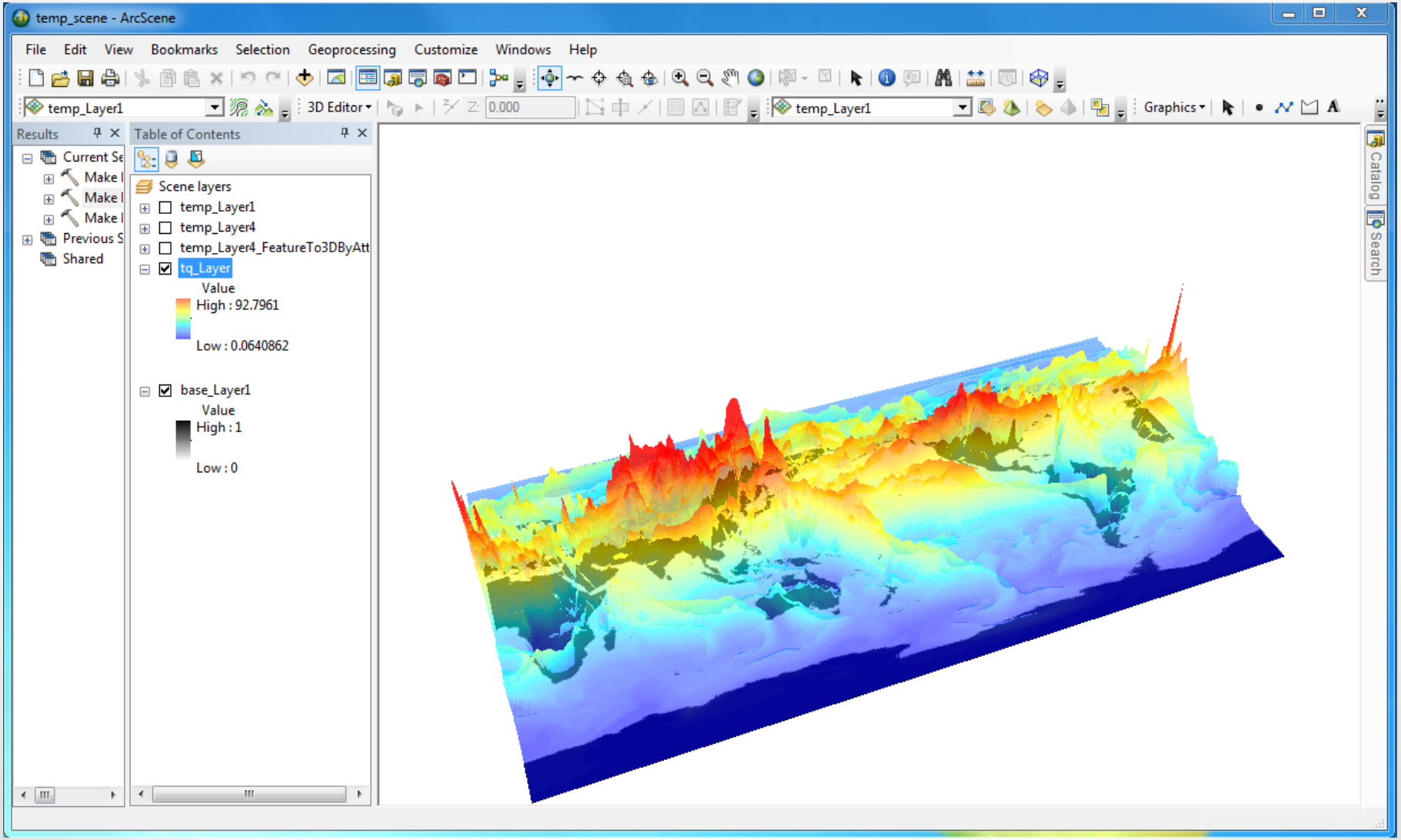
Case 2: 3D Analyst ArcScene



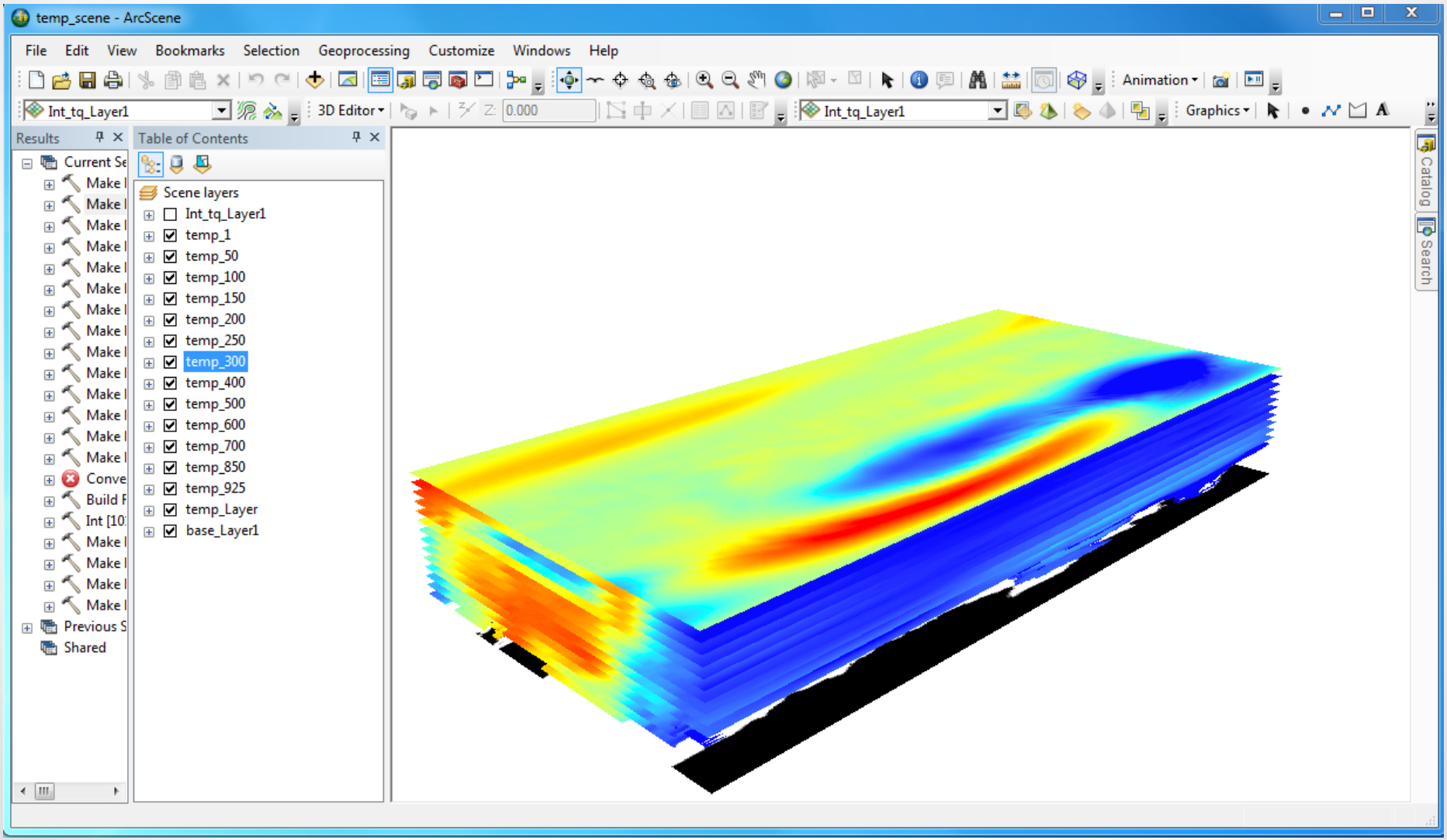
ArcScene


Layer Properties
General
Source
Extent
Display
Symbology
NetCDF
Base Heights
Time
Rendering
Elevation from surfaces
No elevation values from a surface
Floating on a custom surface:
C:\Users\s4m\Downloads\atmos.20140901.nc\temp_Layer1
Raster Resolution...
Elevation from features
No feature-based heights
Use elevation values in the layer's features
Factor to convert layer elevation values to scene units:
custom
1.0000
Use a constant value or expression:
0
Layer offset
Add a constant elevation offset in scene units:
0
About setting base heights
OK
Cancel
Apply

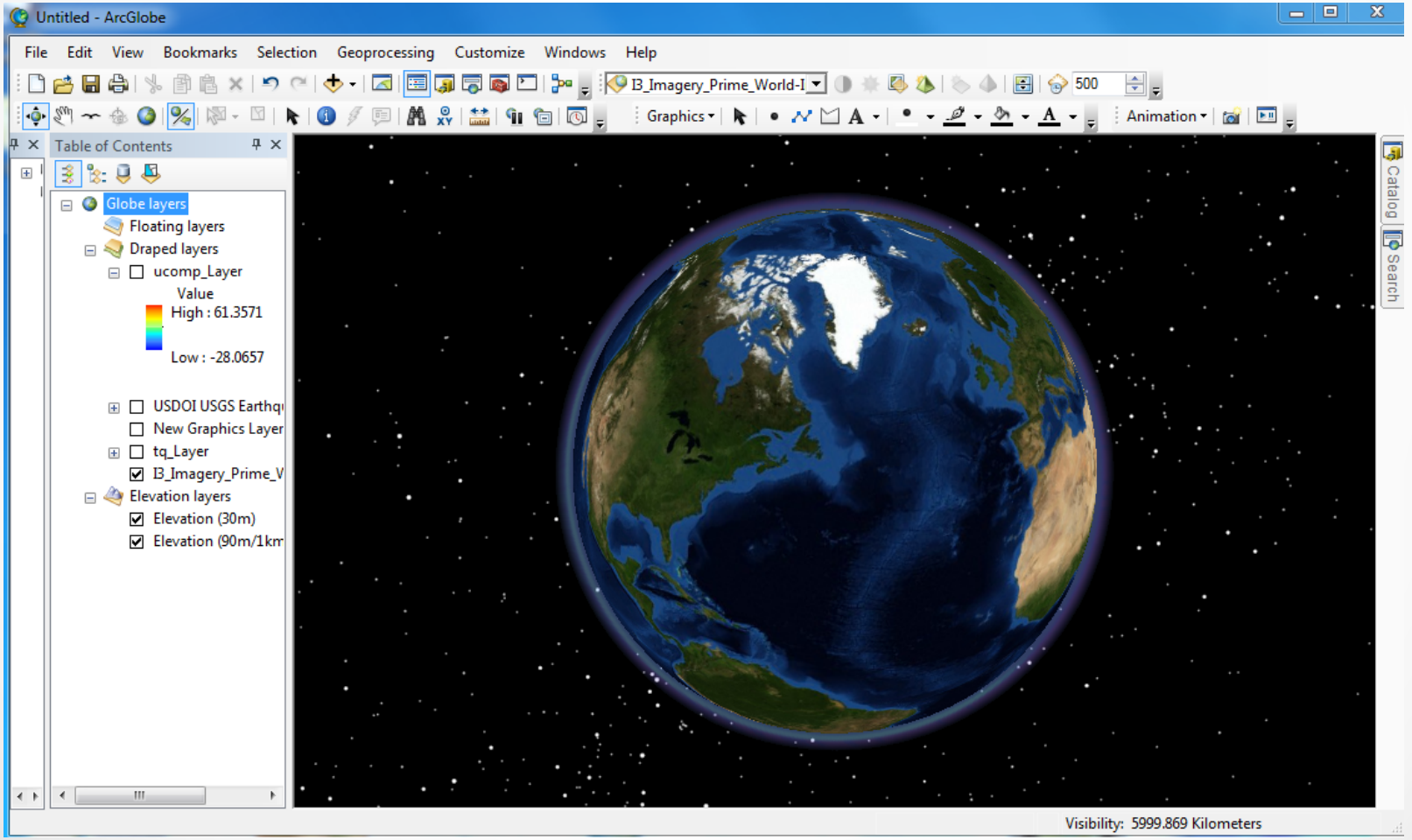
ArcScene


temp_scene - ArcScene
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
temp_Layer1
3D Editor
0.000
temp_Layer1
Graphics
Results
Current Se
Make I
Make I
Make I
Previous S
Shared
Table of Contents
Scene layers
temp_Layer1
temp_Layer4
temp_Layer4_FeatureTo3DByAtt
tq_Layer
Value
High : 92.7961
Low : 0.0640862
base_Layer1
Value
High : 1
Low : 0
Catalog
Search

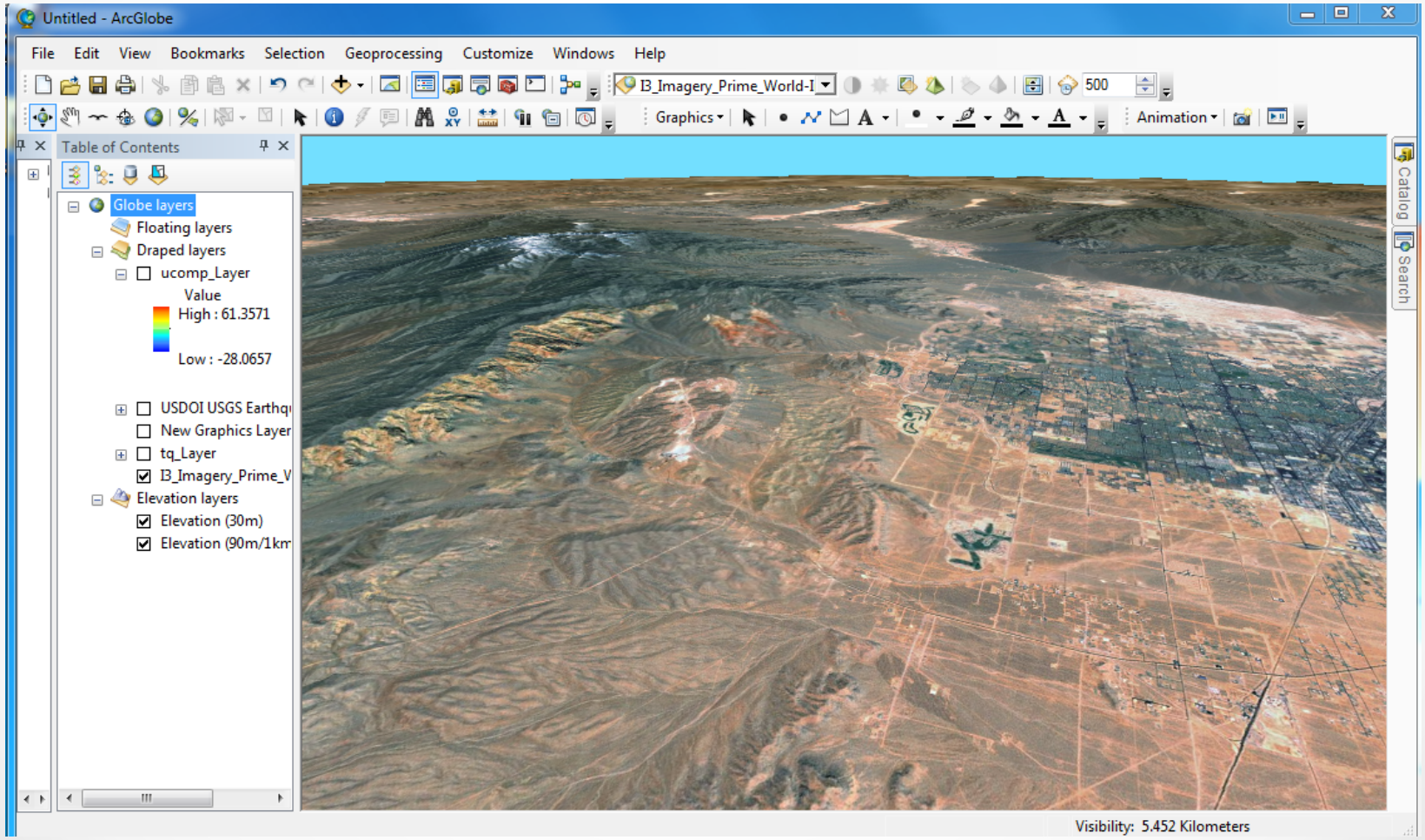
ArcScene


temp_scene - ArcScene
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
Animation
Int_tq_Layer1
3D Editor
0.000
Int_tq_Layer1
Graphics
Results
Table of Contents
Current Se
Make I
Conve
Build F
Int [10
Previous S
Shared
Scene layers
Int_tq_Layer1
temp_1
temp_50
temp_100
temp_150
temp_200
temp_250
temp_300
temp_400
temp_500
temp_600
temp_700
temp_850
temp_925
temp_Layer
base_Layer1
Catalog
Search

ArcGlobe


Untitled - ArcGlobe
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
I3_Imagery_Prime_World-I
500
Graphics
Animation
Table of Contents
Globe layers
Floating layers
Draped layers
ucomp_Layer
Value
High : 61.3571
Low : -28.0657
USDOI USGS Earthq
New Graphics Layer
tq_Layer
I3_Imagery_Prime_V
Elevation layers
Elevation (30m)
Elevation (90m/1km
Catalog
Search
Visibility: 5999.869 Kilometers

ArcGlobe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I3_Imagery_Prime_World-I
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Graphics
Animation
Table of Contents
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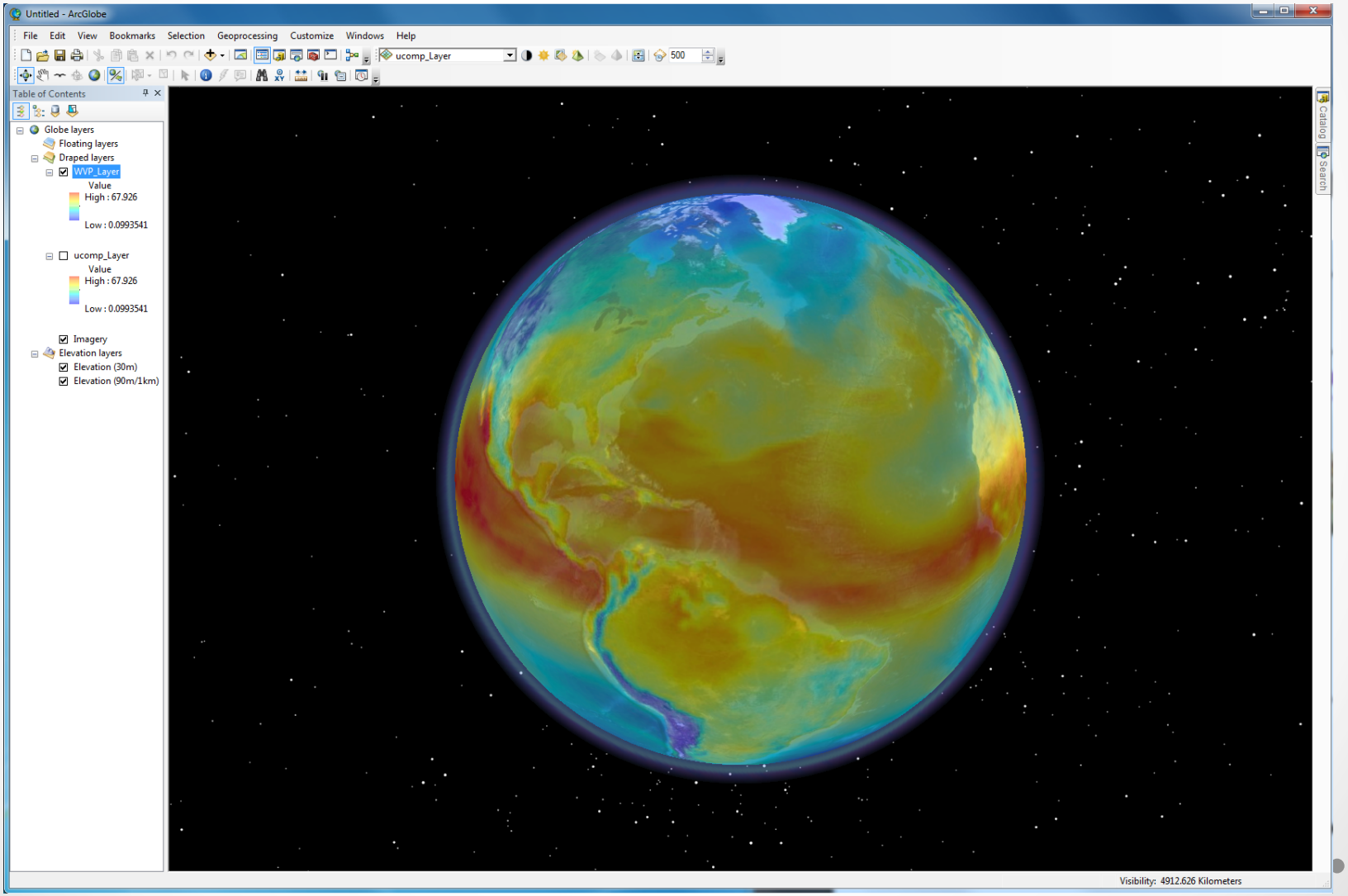
Floating layers
Draped layers
ucomp_Layer
Value
High : 61.3571
Low : -28.0657
USDOI USGS Earthq
New Graphics Layer
tq_Layer
I3_Imagery_Prime_V
Elevation layers
Elevation (30m)
Elevation (90m/1km
Catalog
Search
Visibility: 5.452 Kilometers

ArcGlobe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File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
ucomp_Layer
500
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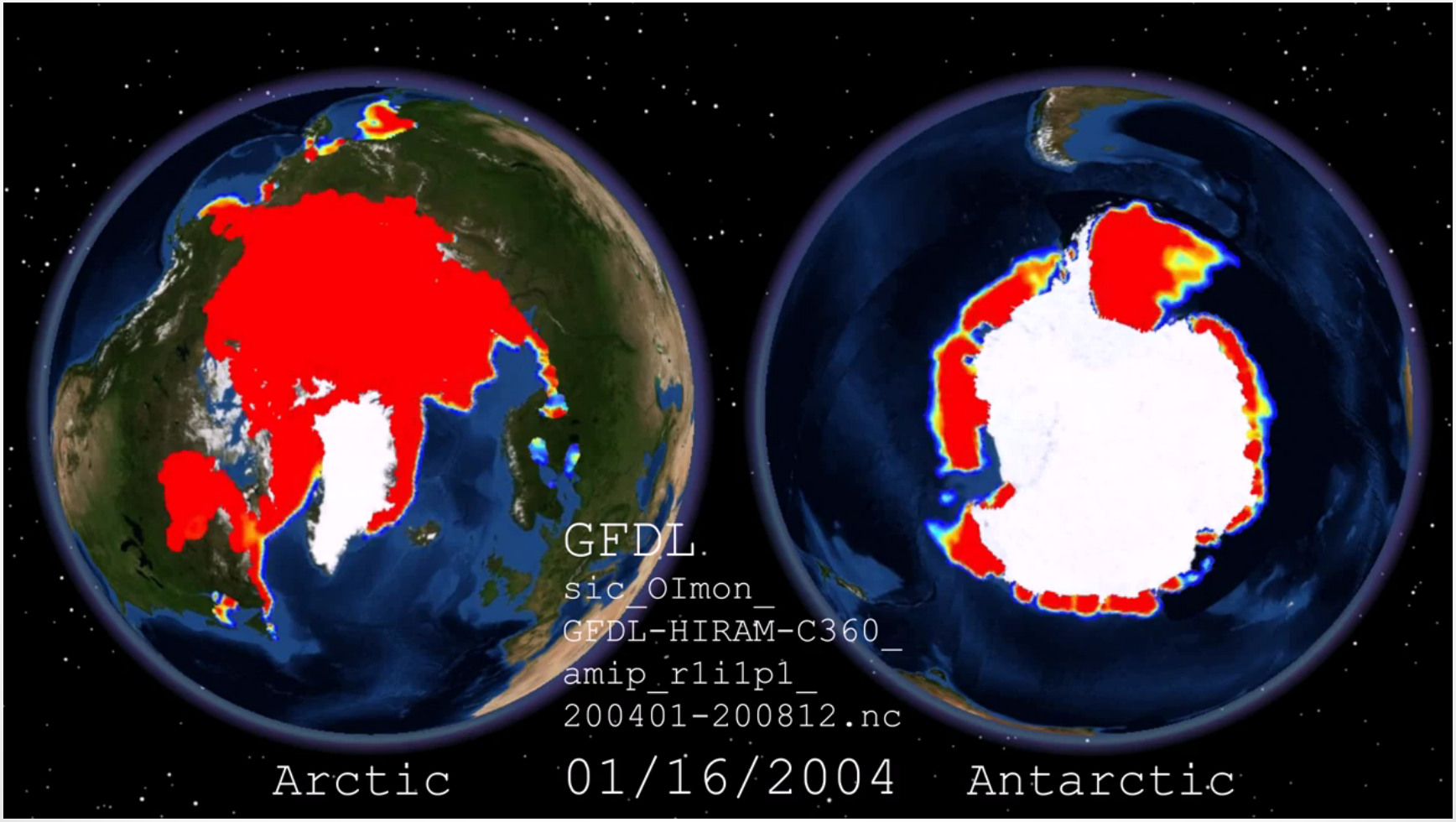
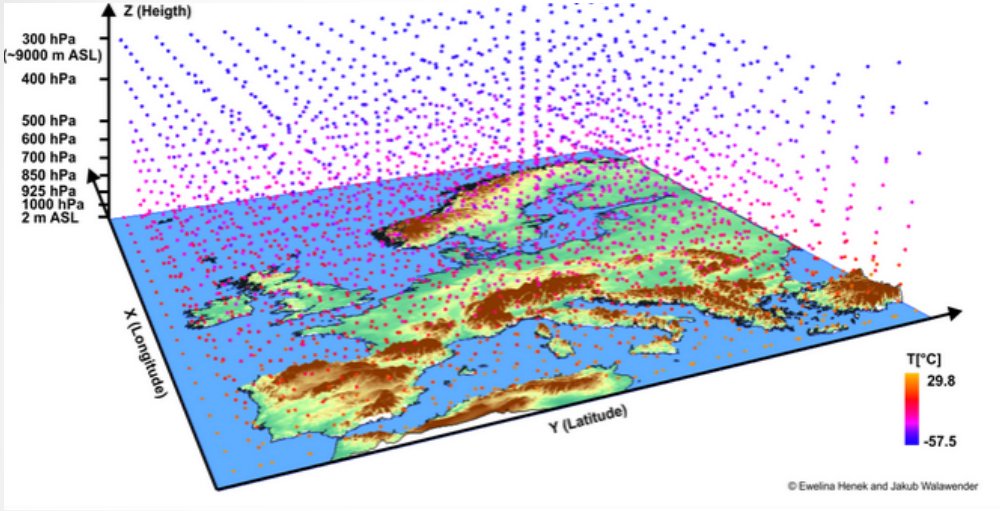
Floating layers
Draped layers
WVP_Layer
Value
High : 67.926
Low : 0.0993541
ucomp_Layer
Value
High : 67.926
Low : 0.0993541
Imagery
Elevation layers
Elevation (30m)
Elevation (90m/1km)
Catalog
Search
Visibility: 4912.626 Kilometers

Sea Ice Area Fraction

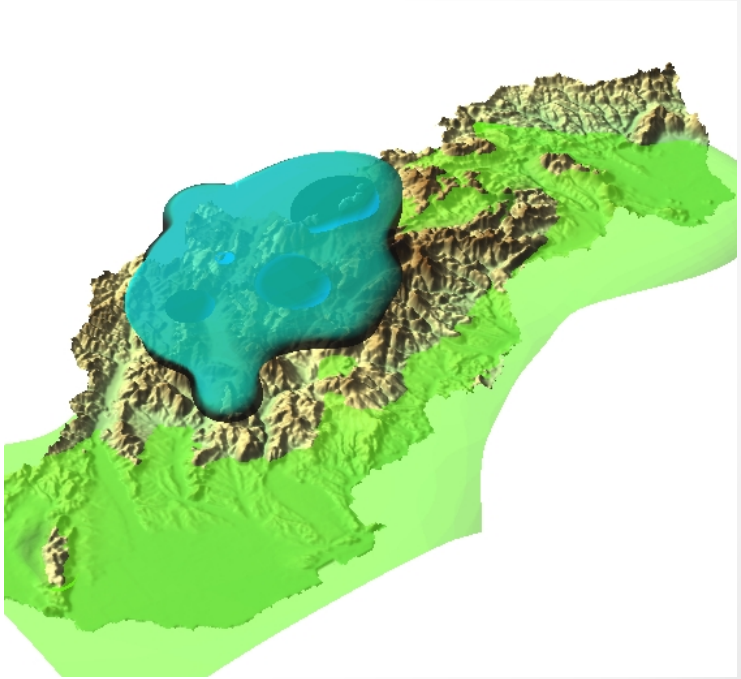
Created by Young Cho



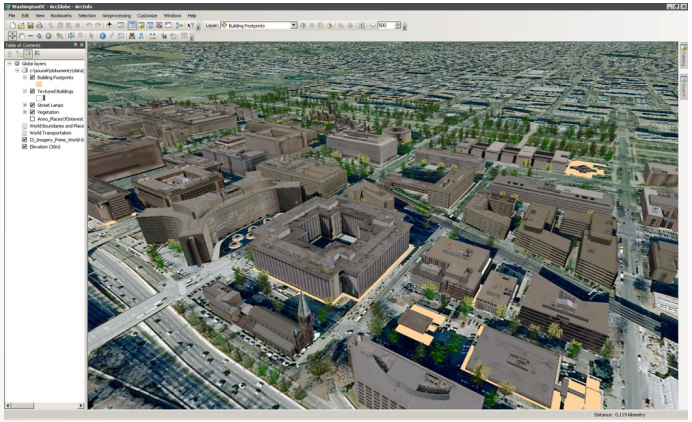
True 3D Analysis



http://ideas.arcgis.com



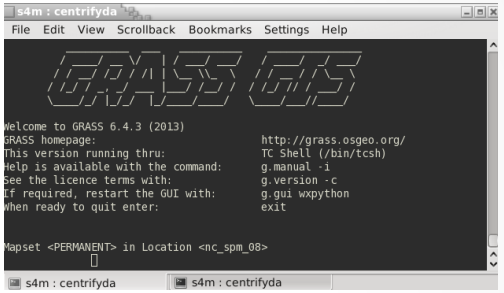
http://grass.osgeo.org

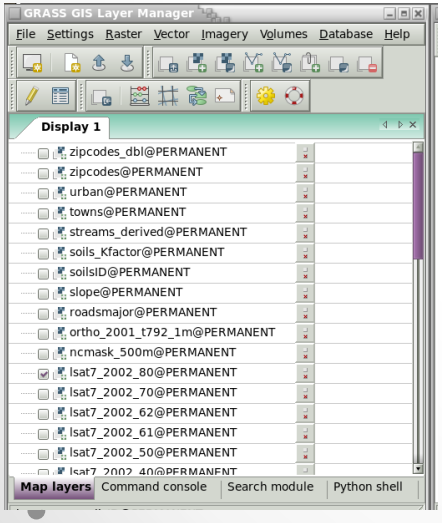


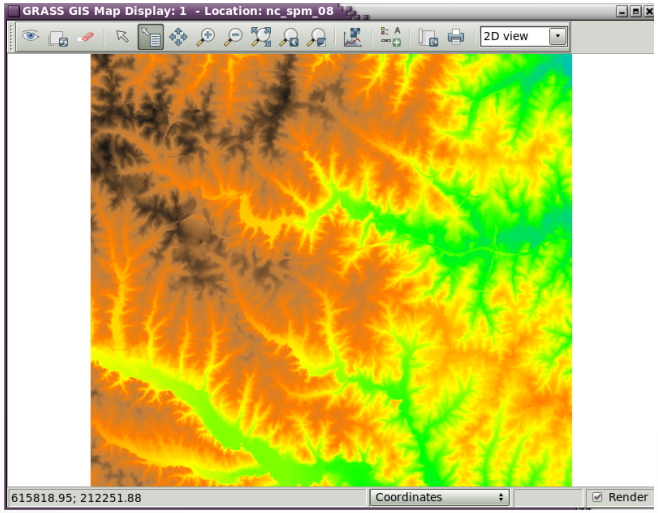
http://www.arcdata.cz

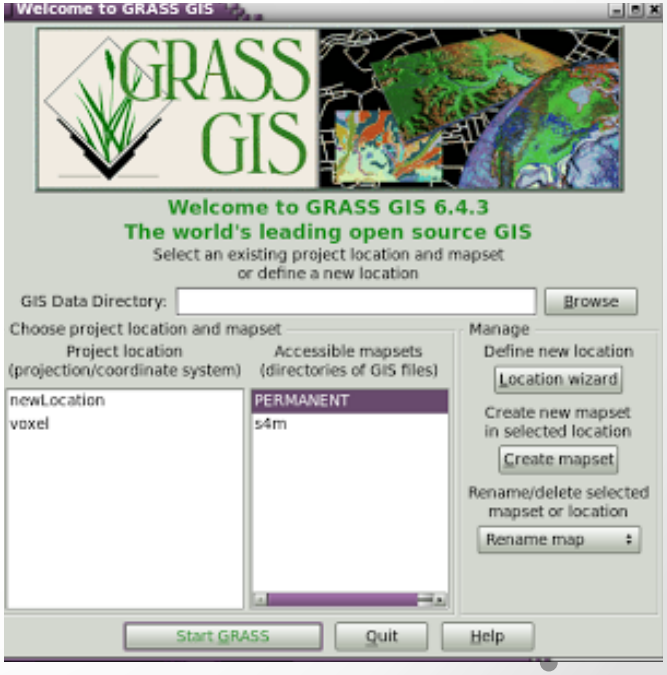
GRASS Free GIS

- See GIS Resources page on GFDL Wiki
- Supports 3D raster voxel volumes:
  - 3D import/export
  - 3D map algrebra
  - 3D volumes interpolation
  - 3D and 4D visualization









Summary

- The ability to display layered data in the spatial dimension makes GIS special
- Interpolating everything to a common grid is an extremely useful way to integrate data
- Makes science communication easier and provides good way to link spatial and non-spatial data
- Easy to use and share spatial data
- The multidimensional nature of atmospheric data remains a challenge across spatial and temporal scales

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